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HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

STUDY OF SEVERN SYSTEM

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS

SEVERN SYSTEM

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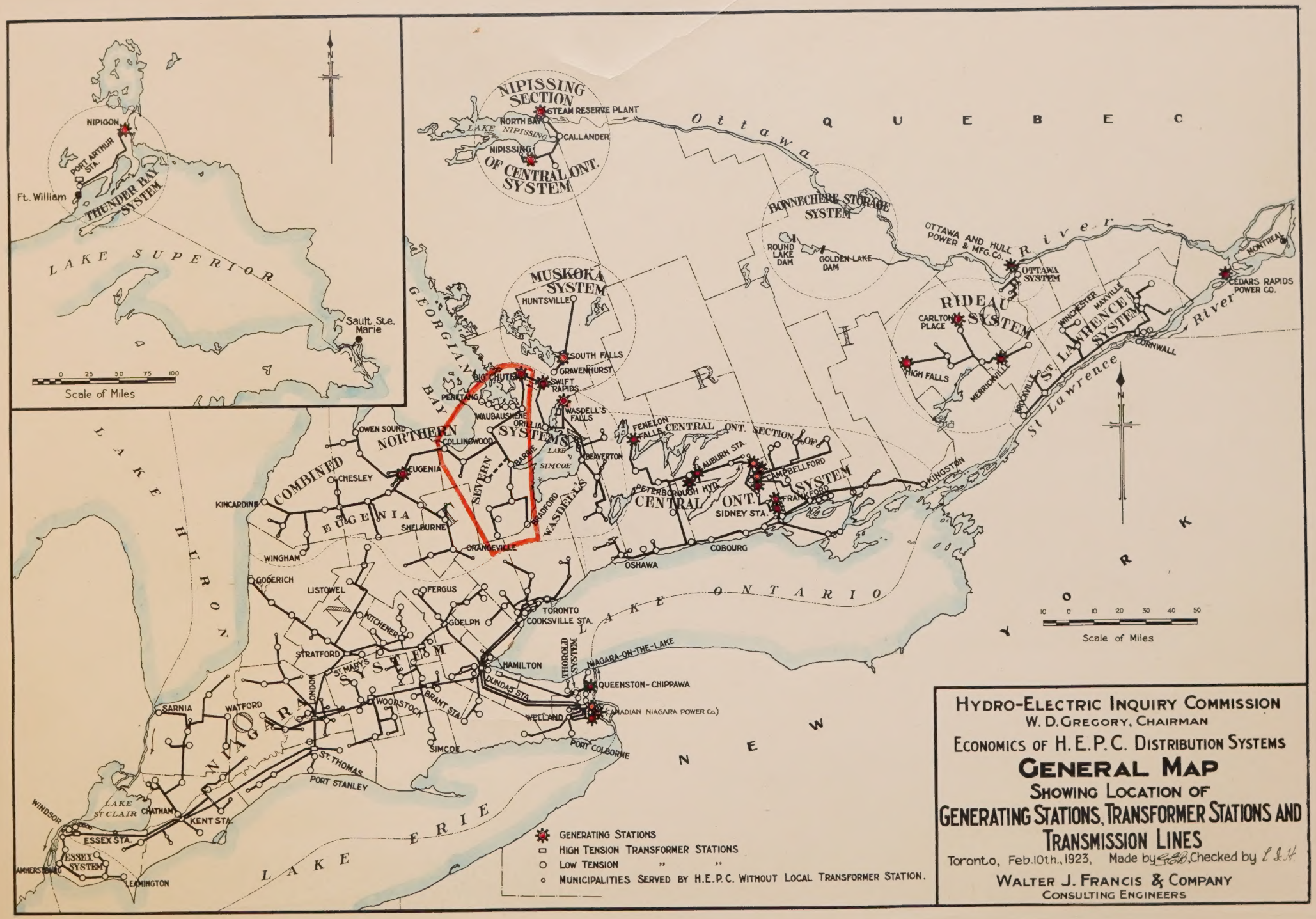
HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H.E.P.C. DISTRIBUTION SYSTEMS
GENERAL MAP
SHOWING LOCATION OF
GENERATING STATIONS, TRANSFORMER STATIONS AND TRANSMISSION LINES
Toronto, Feb. 10th., 1923, Made by S.S.B. Checked by L.S.H.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS
GENERATING STATIONS
HIGH TENSION TRANSFORMER STATIONS
LOW TENSION " "
MUNICIPALITIES SERVED BY H.E.P.C. WITHOUT LOCAL TRANSFORMER STATION.
Scale of Miles
LAKE SUPERIOR
LAKE HURON
LAKE ONTARIO
LAKE ERIE
LAKE ST CLAIR
GEORGIAN BAY
QUEBEC
NEW YORK
Ottawa River
St Lawrence River
NIPISSING SECTION OF CENTRAL ONT. SYSTEM
STEAM RESERVE PLANT
NORTH BAY
CALLANDER
NIPISSING
LAKE NIPISSING
MUSKOKA SYSTEM
HUNTSVILLE
SOUTH FALLS
GRAVENHURST
BIG HUTE
SWIFT RAPIDS
WASDELL'S FALLS
PENETANG
WAUBAUSHENE
ORILLIA
BARRIE
LAKE SIMCOE
BEAVERTON
BONNECHERE STORAGE SYSTEM
ROUND LAKE DAM
GOLDEN LAKE DAM
OTTAWA AND HULL POWER & MFG. CO.
OTTAWA SYSTEM
RIDEAU SYSTEM
CARLTON PLACE
HIGH FALLS
MERRICKVILLE
BROCKVILLE
WINCHESTER
MAXVILLE
ST LAWRENCE SYSTEM
CORNWALL
MONTREAL
CEDARS RAPIDS POWER CO.
FENELON FALLS
CENTRAL ONT. SECTION OF
AUBURN STA.
PETERBOROUGH HYD.
CAMPBELLFORD
FRANKFORD
SIDNEY STA.
KINGSTON
COBOURG
OSHAWA
TORONTO
COOKSVILLE STA.
HAMILTON
DUNDAS STA.
THOROLD SYSTEM
NIAGARA-ON-THE-LAKE
QUEENSTON-CHIPPAWA
(CANADIAN NIAGARA POWER Co.)
WELLAND
PORT COLBORNE
BRANT STA.
SIMCOE
WOODSTOCK
ST. MARYS
LONDON
STRATFORD
KITCHENER
GUELPH
FERGUS
LISTOWEL
GODERICH
WINGHAM
ORANGEVILLE
SHELBURNE
EUGENIA
COLLINGWOOD
OWEN SOUND
CHESLEY
KINCARDINE
NORTHERN SYSTEM
COMBINED EUGENIA
SEVERN
WASDELL'S
BRADFORD
SARNIA
WATFORD
ST. THOMAS
PORT STANLEY
NIAGARA SYSTEM
WINDSOR
CHATHAM
KENT STA.
ESSEX STA.
ESSEX SYSTEM
AMHERSTBURG
LEAMINGTON
NIPIGON
PORT ARTHUR STA.
Ft. William
THUNDER BAY SYSTEM
Sault Ste. Marie
Scale of Miles

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

To face frontispiece.

General Map Showing Location of

Generating Stations, Transformer Stations and Transmission Lines

of the

Hydro-Electric Power Commission of Ontario.

COPY

The area outlined in red shows the

Severn System.

WALTER J. FRANCIS & COMPANY.

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(Index)

INDEX TO SEVERN SYSTEM

COPY

INDEX TO SEWERS SYSTEM

COPY

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COPY FOR ENCLOSURE TO Mr. J. Allan Ross. (Illus.)

LIST OF ILLUSTRATIONS

SEVERN SYSTEM

COPY

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Toronto, Ontario,

February 26th, 1923.

Hydro-Electric Inquiry Commission,
W. D. Gregory, Esq., Chairman,
T O R O N T O, Ontario.

re Studies of Engineering Economics of the
Severn System of the
Hydro-Electric Power Commission of Ontario

Mr. Chairman and Gentlemen,-

In accordance with the letter to your Commission under date of November 4th, 1922, and your confirmation of the general instructions under date of November 15th, 1922, a study has been made of the engineering economics of the Severn System of electrical generation and distribution operated by the Hydro-Electric Power Commission of Ontario. The work has been done under the direct personal supervision of Mr. Frederick B. Brown, M. Sc., M.E.I.C., a partner in the firm of Walter J. Francis & Company, in accordance with your instructions.

COPY

The subject has been discussed with Mr. Commissioner E. A. Ross in detail, and, generally, with Mr. Bower, the Secretary of your Commission, and constant communication has been maintained with the officials of the Hydro-Electric Power Commission of Ontario.

The reports of Messrs. Price, Waterhouse & Co. have been used as the basis of the financial figures given herein, and reference has been made to the records of the Hydro-Electric Power Commission of Ontario where it was necessary to do so to prepare the diagrams.

It is understood that it is not within the scope of the instructions to examine into any of the legal aspects of the System nor discuss any of the Acts of the Legislature relating to it.

The necessary technical data has required considerable preparation, as much of it is only available in the operating records of the Hydro-Electric Power Commission of Ontario. The printed reports contain a part, but these have had to be supplemented by interviews with various officials, and by searching the voluminous records both at the head office in Toronto and elsewhere.

The general plan under which the report of the studies is presented may be outlined as follows:

COPY

(1) A short review of the history and evolution of the System.

(2) A brief physical description of the System.

(3) A brief discussion regarding the characteristics of the local market.

(4) A discussion of progressive capital costs.

(5) Statistics regarding progress revenues for various classes of service with discussion thereon.

(6) Statistics regarding progressive operating costs and fixed charges with discussion thereon.

(7) Statistics showing progressive and accumulated deficits or surpluses with discussion thereon.

(8) Analysis of progressive operating records and of unit revenues per kilowatt-hour and per horse-power per annum and of unit costs per kilowatt-hour and per horse-power per annum.

(9) A brief discussion of the various important points concerning the System.

The report included herewith as pages 4 to 58 inclusive refers in detail to that portion of the activities of the Hydro-Electric Power Commission known as the Severn System. References are made to the possible inter-connection of this System with other systems.

Through the report diagrams have been included in the order of the text, while the map included as a frontispiece shows the System generally and its geographical relation to all the other systems operated by the Hydro-Electric Power Commission of Ontario.

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WALTER J. FRANCIS & COMPANY.
COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

SEVERN SYSTEM

Frederick B. Brown, M. Sc.

Evolution and Development of the System.

The Severn System had its inception when the Hydro-Electric Power Commission of Ontario began supplying the two towns of Midland and Penetanguishene with power purchased from the Simcoe Railway and Power Company.

In September 1909, the Simcoe Railway and Power Company of Midland secured a Crown lease permitting them to develop power at the Big Chute on the Severn River to the full capacity of the site, the object being to transmit power to the towns of Midland and Penetanguishene. The Big Chute generating station was built by this Company and was put into service in 1911.

COPY

The Hydro-Electric Power Commission, in November 1910, made a survey and estimated the cost of power supply to Midland and Penetanguishene, and then made a contract with the Simcoe Railway and Power Company to purchase the power required for these two towns. Having built the necessary transmission lines and distributing stations, the Commission began to supply power in July 1911.

By the end of the year 1913, the number of municipalities served with power purchased from the Big Chute plant had increased to seven and the power demand had more than doubled, and at a meeting of the Hydro-Electric Power Commission held on March 24th, 1914, the purchase of the Big Chute plant was considered. As a result, on June 30th, 1914, the Commission purchased from

the Simcoe Railway and Power Company, its power development situated at Big Chute on the Severn River, together with its transmission lines and distributing stations.

The Order-in-Council permitting the purchase was dated June 17th, 1914; it set the purchase price at $475,000 and covered the following:

"(1) The taking over of the property, franchises, easements and leasehold rights covering the development and operation of the water-power known as the Big Chute, and located upon the Severn River in the townships of Machedash and Baxter in the Province of Ontario, and which are now held by the said Company.

"(2) The taking over of power development works and plant and appurtenant structures of the Big Chute.

"(3) The taking over of all transmission lines and sub-stations now owned by the said Company.

"(4) The taking over of the power site at Port Severn now owned in fee simple by the said Company, together with any lands, riparian rights and privileges or easements connected therewith and necessary for the purpose of the power development except such lands therefrom as the Dominion Government may require for the Trent Valley Canal.

"(5) The taking over of such works, assets, easements, franchises, real property and rights, equipment and chattels, now held by the said Company as may be owned and controlled by them and necessary for the purposes of the Commission for the sum above named.

"(6) The authority to further develop the water powers at the Big Chute, and at Port Severn to full capacity when the necessity for doing so shall arise, and to purchase all necessary material and equipment in connection with such development."

The Commission acquired the properties, subject to the electrical power contracts of the Simcoe Railway and Power Company with the Village of Victoria Harbour, the Victoria Harbour Lumber Company, the Town of Orillia and the Marconi Telegraph Company of Canada, and agreed to carry out the contracts in accordance with the terms thereof.

On October 1st, 1912, Mr. H. G. Acres, Hydraulic Engineer of the Hydro-Electric Power Commission of Ontario, had reported to Sir Adam Beck (then Mr. Beck), giving a detailed valuation of the system of the Simcoe Railway and Power Company.

COPY

and naming the sum of $400,000.00 as an outside purchase price, but this figure apparently did not include the undeveloped power site at Port Severn which was owned in fee simple by the Company.

The actual cost of the properties, apparently including the Port Severn site, as entered in the records of the Hydro-Electric Power Commission is given as $475,355.01. The following table shows an itemized comparison between the estimate of October 1912 and the cost as at June 1914.

Items	H.E.P.C. Valuation Oct. 1, 1912	Cost as at June, 1914
Big Chute generating plant with step-up transformers	$231,000.00	$225,518.01
Transmission Lines	91,000.00	96,471.00
Distributing Stations	21,000.00	24,555.00
Victoria Harbour System. (sold to Victoria Harbour prior to October 31st, 1915)	-	4,800.00
Miscellaneous and Intangibles	57,000.00	124,011.00
Totals	$400,000.00	$475,355.01

COPY

The item for miscellaneous and intangible costs apparently includes in the purchase price the Port Severn site not originally included in the valuation, the leasehold rights at Big Chute and the unexpired power contracts and franchises then held by the Company.

Previous to the acquisition of the Big Chute plant the Commission had purchased all the power for the Severn System from the Simcoe Railway and Power Company from the Big Chute plant. Since the date of purchase of the plant, the power required has been generated at the Big Chute plant and purchased from the Eugenia and Vasdell's Systems.

In 1914, seven municipalities were taking power from the Commission, and this number has steadily increased until at October 31st, 1911, seventeen

municipalities and three other customers were supplied. A list is given on page 18.

With the exception of the agreement with Victoria Harbor, the electrical power contracts in force at the date of purchase of the Simcoe Company properties were superseded by new agreements providing for the municipalities assuming their proportion of the capital cost of the newly acquired properties.

Description of the System.

General.

COPY

The Severn System supplies the territory in the northern and central portions of Simcoe County, between Georgian Bay and Lake Simcoe, the power being obtained from a hydro-electric plant rated at 4,600 horse-power capacity at 80 per cent. power factor, situated on the Severn River at Big Chute, nine miles from its mouth.

The map included as a frontispiece shows the whole of the transmission system of the Hydro-Electric Power Commission, with the location of generating stations, high voltage transformer stations, high voltage transmission lines and low voltage transformer stations, clearly indicated, and shows the various systems in their relation to one another. The tinted portion of the map indicates the Severn System.

The map included as page 3, shows the Severn System on a larger scale


HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
EUGENIA, SEVERN AND WASDELL'S SYSTEMS, AND MUSKOKA SYSTEM
MAP SHOWING LOCATION OF GENERATING STATIONS, TRANSFORMER STATIONS AND TRANSMISSION LINES
Toronto, Feb. 26th., 1923. Made by Checked by
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS
GENERATING STATIONS
LOW TENSION TRANSFORMER STATIONS
MUNICIPALITIES SERVED BY H.E.P.C. WITHOUT LOCAL TRANS'R STATIONS.
NOTE:-
TRANSMISSION LINE VOLTAGE SHOWN THUS 22,000
Scale of Miles
10 5 0 10 20 30 40
GEORGIAN BAY
LAKE HURON
NOTTAWASAGA BAY
LAKE SIMCOE
MUSKOKA
EUGENIA SYSTEM
SEVERN SYSTEM
WASDELL'S SYSTEM
MUSKOKA SYSTEM
Magnetawan River
Parry Sound
HIGH FALLS SITE
Moon River
Muskoka River
Bala
BIG CHUTE
SWIFT RAPIDS
SOUTH FALLS
WASDELL'S FALLS
Severn River
Port Severn
PENETANG
MIDLAND
PORT McNICOLL
VICTORIA HARB.
WAUBAUSHENE
COLDWATER
ORILLIA
BRACEBRIDGE
GRAVENHURST
HUNTSVILLE
PORT SIDNEY
BAYSVILLE ROAD
DAM
STEAM RESERVE PLANT
OWEN SOUND
PORT ELGIN
TARA
KILSYTH
CHATSWORTH
KIMBERLEY
MARKDALE
EUGENIA
DAMS
OLLINGWOOD
STAYNER
ELMVALE
BARRIE
CAMP BORDEN
THORNTON
COOKSTOWN
ALLISTON
BEETON
TOTTENHAM
BRADFORD
GREEMORE
PEVERSHAM
HORNINGS MILLS
SHELBURNE
ORANGEVILLE
ALTON
GRAND VALLEY
ARTHUR
PRICEVILLE
DUNDALK
FLESHERTON
WHAYWADOS
DURHAM
MOUNT FOREST
HOLSTEIN
ELMWOOD
CHESLEY
HANOVER
NEUSTADT
CARLSRUHE
WALKERTON
TEESWATER
WINGHAM
KINCARDINE
RIPLEY
HOLYROOD
LUCKNOW
BRECHIN
CAMBRIDGE
BEAVERTON
KIRKFIELD
KIRKFIELD STONE QUARRY
LORNEVILLE
WOODVILLE
CANNINGTON
SUTTON
GREENBANK
UXBRIDGE
PORT PERRY
Sauguen R.
Saugeen R.
Rocky R.
Sydenham River
Beaver R.
Owen Sound River
Carried by Dom. Gov.
4,000
22,000

(8)

than the frontispiece and gives also the names of the principal centres concerned. It shows also the Eugenia and Wasdell's Systems which are interconnected with the Severn System for convenience and economy of operation, these three systems together being known in the records of the Hydro-Electric Power Commission of Ontario as the Combined Northern Systems.

Speaking generally, the Severn System consists of a hydro-electric generating plant at Big Chute on the Severn River, tie lines to permit the interchange of power between the Severn, Eugenia and Wasdell's Systems, and transmission lines and distributing stations feeding seventeen municipalities, and some rural lines.

COPY

Generating Station and Other Sources of Power Supply.

The Big Chute plant is the only generating station on the Severn System at present owned by the Hydro-Electric Power Commission of Ontario.

This development is located on the Severn River about nine miles from the mouth and includes dams at the head of each of the three channels into which the river divides at this point. The dam at Big Chute, the principal point of discharge, is fifty feet long and eighteen feet high, constructed of concrete piers and sills with stop-logs and spill-crests. Pretty Channel dam is of somewhat similar construction, with no spill-crest. Lost Channel dam is in a narrow gorge and is of concrete and contains one spill-way. Near Big Chute dam a canal 32 feet wide and 500 feet long has been cut through the rock and leads to a forebay, from which at the present time the water is carried through two nine-foot penstocks, 150 and 170 feet long respectively, to

the concrete power house where a 56-foot head is available. The second of these two penstocks was installed in 1918.

The original equipment consisted of three 1,300 horse-power turbines, each direct-connected to a 900 K.V.A., 3-phase, 60-cycle, 2,200-volt, horizontal type generator, with two independent 100-kilowatt exciter units, and six 600-kilowatt station transformers stepping the voltage up from 2,200 to 25,000 volts.

This station was put into service in 1911, being then the property of the Simcoe Railway and Power Company, but in 1914 it was purchased by the Hydro-Electric Power Commission of Ontario to supply power to the Severn System. On account of the rapid increase of the load on the Severn System, it became necessary, early in 1917, to proceed with the extension of the Big Chute generating station. The second steel penstock, 9 feet in diameter and 170 feet long, was purchased from the Dominion Bridge Company of Montreal. A double runner, spiral case turbine of 2,300 horse-power capacity under 56 feet head, running at 300 revolutions per minute, was supplied by the Wellman-Seaver-Morgan Company, and two 66-inch gate valves were installed, and a 1,600 K.V.A., 3-phase, 60-cycle, 2,200-volt, horizontal type generator was purchased from the Canadian General Electric Company, and finally put into commercial service on January 28th, 1919.

COPY

The original capacity of the plant, in accordance with the rating of the Hydro-Electric Power Commission of Ontario, was about 2,900 horse-power at 80 per cent. power factor, while the present capacity is about 4,600 horse-power.

The balance of the power required for the Severn System is purchased from

adjacent systems as described below.

Parallel Operation of Severn, Eugenia, Wasdell's and Orillia Systems.

Towards the middle of the year 1916 the load on the Big Chute plant exceeded its normal capacity due to the increase of the power demand of the municipalities on the Severn System and especially due to the requirements of the municipality of Orillia. This municipality had a contract with the Hydro-Electric Power Commission of Ontario to supply the Orillia Water and Light Commission with power, when such was required to supplement the supply from the Orillia Commission's own plant, situated at Ragged Rapids about ten miles up the Severn River from Big Chute.

COPY

To assist the Big Chute station it was decided to construct a tie line between it and the Wasdell's Falls station on the Wasdell's System, so that the excess power of the Wasdell's station, which was only lightly loaded, might be supplied to Orillia. A single circuit, 22,000-volt line of No. 1/0 aluminum, seven miles in length, was erected between the Wasdell's power house and the substation of the Orillia Commission located at Longford, north-east of Orillia. The tie line between the Wasdell's and Severn Systems was completed by utilising the existing 22,000-volt lines of the Orillia Commission, which had already been in service for some years, from Longford to the Orillia switching station near Ragged Rapids and thence to the Big Chute plant.

The two generating stations at Big Chute and at Wasdell's Falls were placed in normal parallel operation on July 24th, 1916, and the Wasdell's

station then supplied practically all of the Orillia load previously taken from the Big Chute station by the Orillia Commission. Two important objects were gained, the Wasdell's station was loaded to a point of economical operation and the load on the Big Chute station was reduced.

The power supply of the Severn System was further augmented in 1916 by the paralleling of the Eugenia Falls station with the Big Chute station. This was accomplished by the erection of a 22,000-volt tie line on No. 1/0 copper, twenty-four miles long, between the Eugenia Falls power house and the Collingwood distributing station on the Severn System. Power from the Eugenia System was first supplied to the Severn System on October 5th, 1916.

COPY

The Orillia Commission's power plant at Ragged Rapids on the Severn River about ten miles above Big Chute was put into service in 1901, but, on account of unsatisfactory local conditions, had not been able to deliver full capacity continuously. The Orillia Commission therefore made arrangements with the Simcoe Railway and Power Company for power from the Big Chute plant to augment the supply from Ragged Rapids during certain periods. This contract was still in force when the Big Chute plant was purchased by the Hydro-Electric Power Commission of Ontario. Later, the Orillia Commission decided to construct a new plant at Swift Rapids near Ragged Rapids where there was a satisfactory location and where a head of 47 feet was available instead of the 41 feet at Ragged Rapids. Towards the end of 1917 the new plant at Swift Rapids was ready for service and the old plant was abandoned. The Hydro-Electric Power Commission of Ontario soon afterwards purchased from the Orillia Commission seven and one-half miles of 22,000-volt, single circuit, three-phase line of

No. 2 aluminum conductor to form a tie line between the Big Chute plant and the new development at Swift Rapids.

Regular parallel operation of the Eugenia, Big Chute, Swift Rapids and Wasdell's plants was begun on June 1st, 1918, and has thereafter been continued, proving of great advantage to all the systems concerned.

The high head and the large local reservoir capacity of the Eugenia development make it unusually serviceable as a peak load plant. Off-peak power from the Severn and Wasdell's Systems which could not otherwise be utilized has been and may be, transferred to the Eugenia System, allowing the Eugenia plant, by operating at a variable load, to conserve the stored water and make it available to supply peak loads on the combined systems. The transfer of power from one system to another is therefore beneficial to all, and it is understood that book-keeping credits and debits as between the various systems concerned are kept in the books of the Commission. Up to October 31st, 1920, the electrical power delivered by one system to another was apparently charged for on the basis of $25.00 per horse-power. It is stated that in 1921 it was decided by the Hydro-Electric Power Commission that, beginning with 1921, the interchange of power between these systems would be at cost and not at a fixed rate.

COPY

The tie lines to adjacent systems and plants on adjacent systems making available to the Severn System power from the Orillia, Eugenia and Wasdell's Systems therefore constitute an additional source of power for the Severn System.

The amount of continuous power available from the Eugenia System for the

Severn System is now very small and practically none has been billed from Eugenia during the last three years. Nevertheless, the Severn System makes use of the peak capacity of the Eugenia plant and the Eugenia System draws a considerable amount of off-peak power from the Severn System.

Undeveloped Power Sites, Severn System.

The only undeveloped power site of commercial capacity on the Severn System is that near Port Severn on the Severn River, a short distance downstream from Big Chute. Some details of this site are given in the table below, the data being supplied by the Hydro-Electric Power Commission. This power site was taken over by the Hydro-Electric Power Commission with the other properties of the Simcoe Railway and Power Company when the Big Chute development was purchased.

COPY

Data on Undeveloped Power Site at Port Severn

1. Name of River	Severn - near Port Severn and Big Chute.
2. Drainage Area, Square Miles	2,265
3. Minimum Precipitation per Annum in Inches	24.2
4. Mean Precipitation per Annum in Inches	32.5
5. Minimum Mean Monthly Run-off C.F.S.	1,000*
6. Mean Run-off per Annum C.F.S.	2,500
7. Minimum Available Head, Feet	12.5
8. Mean Available Head, Feet	12.5
9. Years of Precipitation Records	1873 - 1916
10. Years of Gauging Records	1913 - 1918
11. Water Horse-power, mean	1,400
12. Water Storage, Million Cubic Feet	15,500

* Estimated minimum run-off as regulated.

In the above table it will be noted that the minimum mean monthly run-off is given at 1,000 cubic feet per second, which the engineers of the Hydro-Electric Power Commission of Ontario estimate to be the minimum flow from the regulation of the river. It is understood that at the present time the flow in the river is excessively low, Lake Simcoe being at a very low stage. It will also be noted from the table that the head is given at 12.5 feet. The Port Severn site, being situated near Gloucester Pool, is subject to fluctuations in the tail-water as Lake Huron rises and falls.

For a number of years past there has been a dam and lock at Port Severn, built by the Federal Government in connection with the Trent Canal works. It is stated by the Trent Canal officials that the normal lift at this lock is 14.5 feet. When the dam and lock were built, provision was made in the design for the future connection of a power plant at this point, and it is understood that the Hydro-Electric Power Commission of Ontario intends to take advantage of the partly developed conditions at Port Severn by installing a power development during the present year. It is stated by the engineers that the estimated expenditures for 1922 and 1923 include a sum of $275,000 for the development of the power plant at Port Severn. The dependable power from this site with a flow of 1,000 cubic feet per second, and a head of 12.5 feet, would be about 1,200 horse-power, continuous capacity, but allowing for the pondage effect above the dam it is likely that a large capacity might be installed to advantage. Having regard to the uncertainty in the regulated flow of the river, and the local conditions at the site, it is probable that from 1,500 to 1,800 horse-power installed capacity is all that might be utilized

COPY

for commercial service.

Miscellaneous Power Plants in the District.

With the single exception of the Swift Rapids development of the Orillia Water and Light Commission there are no power plants in the district which are worthy of note.

In view of the fact that the Swift Rapids plant is operated in parallel with the three plants of the Hydro-Electric Power Commission at Eugenia Falls, Big Chute and Wasdell's Falls, a short description of the development is appended.

COPY

The Swift Rapids development is located on the Severn River between the Wasdell's Falls and Big Chute developments. It is about twenty miles from Orillia and is owned and operated by the municipality of Orillia. The concrete dam forms a part of the Trent Canal System, (Severn Division); it is seventy-five feet high and two hundred and thirty feet long with five stop-log sluices each 20 feet wide. From the northerly end of the dam, three concrete flumes, 55 feet long and 20 feet by 24 feet in section lead to wheel pits adjacent to the concrete power house, where a head of 47 feet is available. Three 2,120 horse-power turbines, each direct-connected to a 1,500 K.V.A., 3-phase, 60-cycle, 2,300-volt generator, supply power to three-phase, 1,500 K.V.A. transformers which step the voltage up from 2,300 to 23,000 volts for transmission to Orillia. The plant gives continuous service and was installed in 1917 at a stated cost of $114,000, exclusive of the building and development,

which it is understood were constructed by the Federal Government. As already mentioned the municipality had, from 1901 to 1917, a plant of about 1,600 horse-power capacity under a head of 35 to 41 feet at Ragged Rapids, which has now been replaced by the present plant.

The only other private plants in the district are the following: in Alliston, the Alliston Electric Light Company has a combined hydraulic and steam plant on the Boyne River driving a 60-kilowatt, 2-phase, 133-cycle, 1,100-volt generator; in Beeton is a municipal steam plant with an output of 25-kilowatt, single-phase, 60-cycle, 1,100 volts; and in Tottenham a municipal steam plant has an output of 47 kilowatts, direct current.

COPY

Transmission Lines.

Up to October 31st, 1921, the Hydro-Electric Power Commission had acquired or constructed 178 miles of high voltage transmission lines including about 7 miles of 4,000-volt lines and about 171 miles of 22,000-volt lines forming a network supplying the various municipalities, and also connecting together for parallel operation the generating stations of the Eugenia, Severn, and Wasdell's Systems and the Swift Rapids station of the Orillia Water and Light Commission.

The transmission system is constructed on wooden poles throughout and presents no extraordinary features. Extensions estimated to cost about $100,000 for each of the years 1922 and 1923 are said to be contemplated covering miscellaneous lines and distributing stations and a considerable extension of the rural lines.

Transforming and Distributing Stations.

The transmission lines feed the various municipalities at low voltage through seventeen substations, which are listed in the table below, showing their voltage and capacity:

Table of Transforming and Distributing Stations

Location	Capacity K.V.A.	Voltage H.V.	Voltage L.V.	Remarks
Midland	900	22,000	2,300	* Has 300 K.V.A. synchronous condenser.
Penetanguishene	600	22,000	2,300	
Collingwood	750	22,000	2,300	* Has 312 K.V.A. synchronous condenser.
Barrie	700	22,000	2,300	Two-phase on the 2,300-volt side.
Coldwater	50	22,000	2,300	
Elmvale	75	22,000	2,300	
Stayner	100	22,000	2,300	Supplies Creemore at 4,000 volts.
Victoria Harbor	100	22,000	2,300	
Waubaushene	50	22,000	2,300	
Port McNicoll and C.P.R. Elevator	1,500	22,000	2,300/575	
Camp Borden	375	22,000	2,200	
Cookstown	75	22,000	2,300/575	Outdoor pole type.
Alliston	225	22,000	2,200	
Bradford	300	22,000	2,300/575	
Beeton	75	22,000	2,300/575	Outdoor pole type.
Tottenham	75	22,000	2,300/575	Outdoor pole type.
Thornton	25	22,000	2,300/575	Outdoor pole type.

*These synchronous condensers are used for power factor correction.

COPY

Local Distributing Systems.

With the exception of the rural lines there are no municipalities on the Severn System in which the Hydro-Electric Power Commission distributes retail power to the consumers. The Commission acts as a wholesale distributor only and in all the municipalities the electricity is distributed by the municipality itself or by local commissions in the municipalities. It is understood that the accounting for all of the municipalities of the Severn System is done in accordance with the standard accounting system of the Hydro-Electric Power Commission, and the details for the various municipalities are given in the Annual Reports.

COPY

Characteristics of Market.

Population Served and Percentage of Consumers to Population.

The district served by the Severn System is both urban and rural, but the bulk of the load is in the towns of Barrie, Collingwood, Penetanguishene and Midland. A large block of power is also supplied to the Canadian Pacific Railway Company for the elevator at Port McNicoll.

The table on the following page gives in detail the number of consumers at the end of the fiscal year 1921 in the places served by the System, the approximate horse-power billed to each place in 1921, the total kilowatt-hours consumed on the System in 1921, together with the average horse-power and average kilowatt-hours per consumer. The figures are useful for comparison with other

systems although they should be used with caution.

Orillia, which is the largest power consumer in the district, is not one of the partner municipalities regularly served by the Hydro-Electric Power Commission of Ontario, but the Orillia Water and Light Commission, which has its own plant at Swift Rapids, has an agreement with the Hydro-Electric Power Commission of Ontario permitting the exchange of power in either direction between the Swift Rapids plant of the Orillia Commission and the Eugenia Falls, Big Chute, and Wasdell's Falls plants of the Hydro-Electric Power Commission, these four plants being regularly operated in parallel, and it has been stated in recent evidence that the Orillia Commission has supplied to the Severn System as much as 2,000 horse-power at one-quarter cent per kilowatt-hour in one year.

COPY

Table of Market Statistics

Municipality	Population 1921	Consumers 1921	Percentage Consumers to Population	H.P. Billed 1921	Kilowatt-hours 1921	Billed H.P. per Consumer	Kilowatt-hours per Consumer
Alliston	1,501	370	28.0	133.5		0.36	
Barrie	6,876	1,643	23.9	788.6		0.48	
Beeton	580	111	19.1	87.5		0.79	
Bradford	907	150	16.5	53.0		0.35	
Coldwater	663	138	20.8	67.9		0.49	
Collingwood	6,016	1,439	23.9	859.0		0.60	
Cookstown	(500)	101	-	57.5		0.57	
Creemore	603	172	28.5	46.2		0.27	
Elmvale	(500)	171	-	150.8		0.88	
Midland	7,129	1,424	20.0	1,218.3		0.85	
Penetanguishene	3,896	492	12.6	759.5		1.55	
Port McNicoll	614	133	21.7	37.7		0.28	
Stayner	927	238	25.7	115.5		0.49	
Thornton	(500)	43	-	12.3		0.29	
Tottenham	452	152	33.6	35.2		0.23	
Victoria Harbor	1,462	133	9.1	47.0		0.35	
Waubaushene	(500)	8	-	23.2		2.90	
Camp Borden				58.2			
C.P.R. Elevator				877.3			
Dept. of Railways and Canals				12.6			
Totals	33,426	6,998	20.9	5,440.8	16,784,781	0.78	2,399

In the Annual Reports of the Hydro-Electric Power Commission the letters P. B. appear in place of population in the cases of a number of the smaller municipalities. In compiling the figures in the Annual Report for total population a round figure of 500 is added for each of these places. This number has been included in this report as the population of each of these places in obtaining the average kilowatt-hours billed per capita for 1921.

The average horse-power billed per consumer and per capita, and the average kilowatt-hours per consumer and per capita, are as follows:

Average Horse-power Billed per Consumer	0.78
Average Horse-power Billed per Capita	0.16
Average Kilowatt-hour Billed per Consumer	2,599
Average Kilowatt-hour Billed per Capita	502

COPY

Growth of Market and Ultimate Sources of Power Supply.

Since the commencement of operations the growth of the System has been fairly steady. The loads on the System were as follows, the figures being given in horse-power for the month of October in each year: 1911, 220; 1912, 540; 1913, 1,283; 1914, 1,630; 1915, 3,370; 1916, 5,885; 1917, 7,853; 1918, 5,780; 1919, 6,202; 1920, 6,411; 1921, 5,698. These figures do not show the actual peak demands of the System, but they do indicate the growth of the demand. The figures for 1915, 1916 and 1917 include large loads supplied to the Orillia Water and Light Commission for munition work and during the construction of the Swift Rapids plant.

Owing to the inter-connection of the Wasdell's, Severn and Eugenia Systems, and the method of keeping the records by the Hydro-Electric Power Commission of

Ontario, it is impracticable to separate the records satisfactorily so as to indicate the actual peak on any one part of the Combined Northern Systems. Briefly, it may be noted that in 1921 the total of loads billed to the municipalities is nearly four times as great as it was in 1914, the year when the Big Chute plant was purchased by the Hydro-Electric Power Commission of Ontario.

The ratio of consumers to population at the end of 1921 was 20.9 per cent. which compares well with other systems. The general growth in the load and in the number of consumers has been comparatively steady making due allowance for the abnormal conditions following the armistice in November, 1918, and the indications are that the demands are still increasing.

COPY

The situation at the present time is that the Severn System is loaded to the full capacity of the Big Chute plant. The Eugenia System is likewise fully loaded and therefore has no spare capacity for the Severn System. It is proposed to develop the Port Severn site but this has a comparatively small capacity and will probably fill the load requirements for a year or two at most. The available power from the Orillia plant at Swift Rapids is very uncertain.

This brings up the question of the ultimate use of power in the district and the future source of power supply. If Niagara power be used it would necessitate the building northwards of a number of short tie lines, which must be connected to the Severn System through frequency changers, since Niagara power is developed at 25 cycles.

To use power from the French River for the Muskoka System and for the Combined Northern Systems, and possibly for the Nipissing Section and for the northerly portion of the Trent Section of the Central Ontario System, long

transmission lines from the French River to Nipissing, and from Nipissing to Muskoka, and from Muskoka to Wasdell's and to the Trent Systems would be required. As all of these systems are operated at 60-cycles, the use of French River power, which is contemplated at 60-cycles, would avoid the use of frequency-changing apparatus. The development of the French River sites would depend on the growth of the load on the Combined Northern Systems, and in the North Bay-to-Sudbury district to a sufficient degree to permit of their economical use. If the general power demand continues to increase at a rapid rate, the total economical capacity of the French River sites, which is probably about 20,000 horse-power, might be reached within a comparatively few years, in which case Niagara power would be the only feasible source of supply. From an operating point of view it would be preferable to use power generated at 60-cycles and avoid the complication of frequency-changers. It is understood that the Hydro-Electric Power Commission contemplates the use of some Niagara power through frequency-changers in the near future, for the Magenia System.

COPY

If Niagara power be used it might prove desirable to separate a number of the municipalities from the present partnership arrangement on the Severn System and add those municipalities to the Niagara System, in which case the accounting should take into consideration the re-allocation of the cost of that portion of the system so affected.

On the other hand, if power be transmitted from the French River, a system of billing for each of the four or five systems affected would have to be developed so as to fairly apportion the costs of the transmitted power.

Capital Costs.

General.

The figures of capital costs given in the table below, and plotted diagrammatically and shown on the sheet of curves on page 26, were obtained from page 19 of the report on the accounts of the Severn System by Messrs. Price, Waterhouse & Co. to the Hydro-Electric Inquiry Commission under date of November 23rd, 1922, except for the years 1912 to 1916 inclusive, which were obtained from the Annual Reports of the Hydro-Electric Power Commission:

COPY

Table of Progressive Capital Costs

Capital Assets	Fiscal Year Ending October 31st. 1912	1913	1914	1915	1916
Power Development	-	-	$349,529	$349,529	$349,787
Transmission Lines	$37,089	$203,322	302,711	316,307	335,497
Distributing Stations	7,436	32,046	39,953	68,751	79,861
Totals	$44,525	$235,368	$692,193	$734,587	$765,145

Table of Progressive Capital Costs (continued)

Capital Assets	Fiscal Year Ending October 31st. 1917	1918	1919	1920	1921
Power Development	$361,506	$551,528	$633,890	$649,767	$652,253
Transmission Lines	408,351	527,295	547,404	552,257	569,977
Distributing Stations	98,491	166,874	168,339	179,250	184,564
Rural Lines (under construction)	-	-	-	-	53
Totals	$868,347	$1,245,697	$1,349,633	$1,381,274	$1,406,847

It will be noted that the total capital costs to the end of 1921, amounting to approximately one million four hundred thousand dollars, is divisible roughly into six hundred and fifty thousand dollars for the plant at Big Chute, five hundred and seventy thousand dollars for transmission lines, and one hundred and eighty-five thousand dollars for transforming and distributing stations.

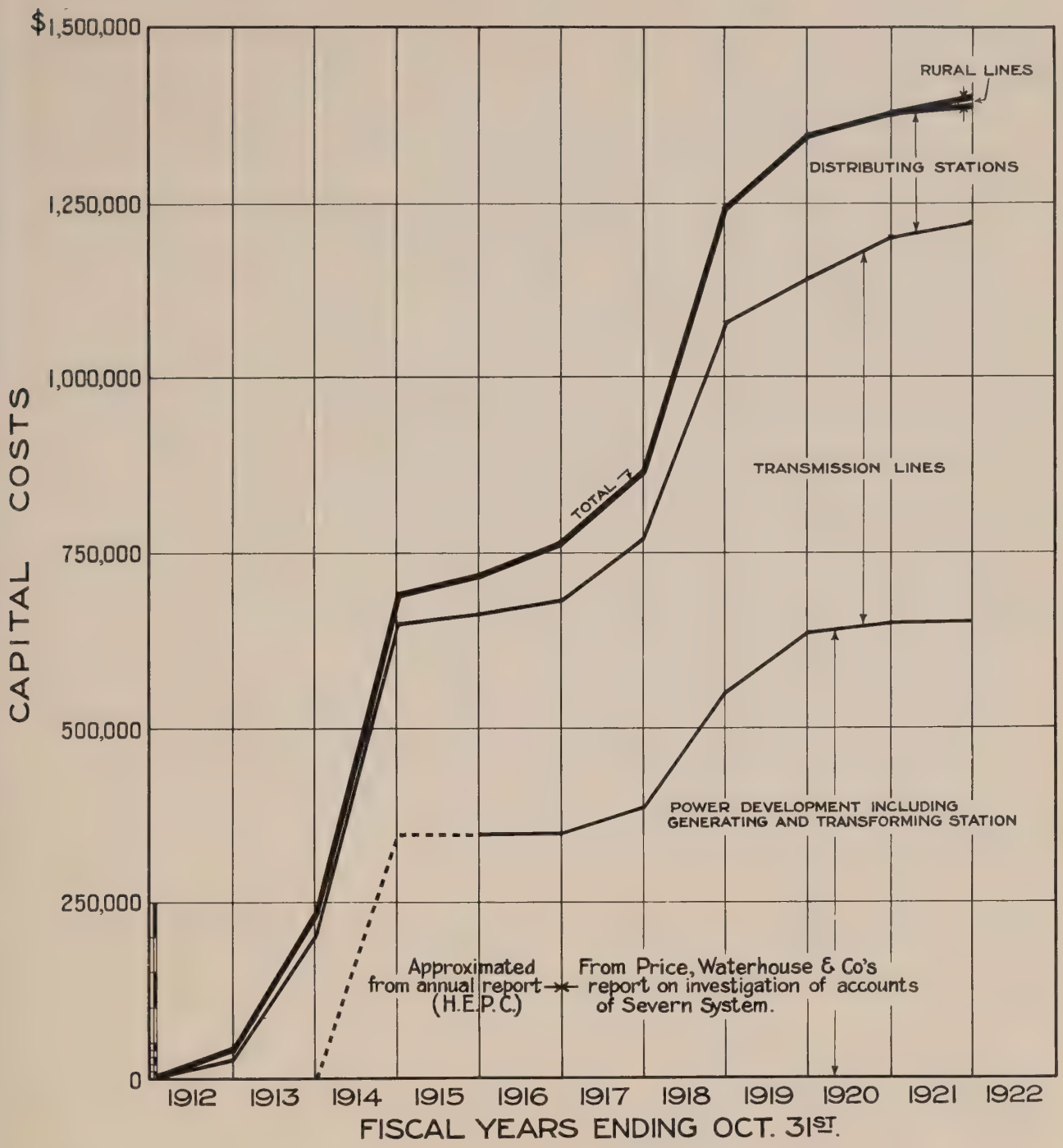
The increase in the investment in power development from 1917 onwards is accounted for principally by the expenditure of $272,384.86, covering the cost of installing the additional unit with the necessary penstock and equipment in the generating plant at Big Chute, and the erection of a machine shop and its equipment, amounting to $15,877.48.

COPY

The increase in the investment in transmission lines is made up principally of the cost of constructing new lines to serve the municipalities of Alliston, Cookstown, Beeton, Tottenham and Bradford amounting to $118,944.28; the purchase from the town of Orillia of the transmission line between Big Chute and Swift Rapids, amounting to approximately $20,000; and sundry extensions and additions to existing lines, including $17,643.32 for new conductors on the Big Chute to Waubaushene line.

The increase in the investment in distributing stations represents expenditures to and additional equipment installed in the sixteen stations on the System.

The expenditures on rural lines increased from $53.42 at October 31st, 1921 to $14,486.66 at October 31st, 1922. It has been estimated that additional funds of $125,000 and $350,000 respectively will be required by the Severn



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

SEVERN SYSTEM

PROGRESSIVE CAPITAL COSTS

Toronto, Feb. 26th., 1923. Made by Checked by

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

System in the fiscal years 1922 and 1923, for the following purposes:

	1922	1923
Port Severn Development	$ 25,000	$250,000
Miscellaneous Lines and Stations	50,000	50,000
Rural Lines	50,000	50,000
Totals	$125,000	$350,000

If these expenditures are made, the total investment in the Severn System at the end of 1923 will be approximately one million nine hundred thousand dollars, of which about one-half would be for generating plants and the balance for lines and stations.

The present subdivided costs of the Big Chute plant are as follows: lands and water rights, $1,540; dams and water structures, $143,865; power house, $57,646; equipment, $325,190; intangibles, $124,011; total $652,252.

COPY

Power Data.

The table below and the diagram on page 29 have been prepared to show the characteristics of the Severn System in terms of horse-power:

Table of Horse-power Developed, Consumed, Billed, etc.

	Fiscal Year Ending October 31st.					
	1914-1917	1918	1919	1920	1921	1922
H.P. Developed	2,900	2,900.0	4,600.0	4,600.0	4,600.0	4,600.0
H.P. Purchased	-	1,746.7	1,698.9	513.7	472.6	-
H.P. Developed plus Purchased	2,900	4,646.7	6,298.9	5,113.7	5,072.6	4,600.0
H.P. Consumed, Average	-	-	-	-	2,568.0	3,060.0
Total H.P. Billed	-	5,910.6	5,829.4	5,692.7	5,440.8	5,404.0
H.P. Billed to System from Big Chute		4,163.9	4,122.5	5,179.0	4,968.2	4,968.2

It will be noted that there are six different classes of horse-power shown in the table and on the diagram. These may be explained as follows:

Developed Horse-power.

The figures for plotting the curve showing the developed horse-power were obtained from the records of the Hydro-Electric Power Commission and are the sum of the capacities of the various units installed in the Big Chute station expressed in horse-power at 80 per cent. power factor according to the usual Hydro-Electric Power Commission rating.

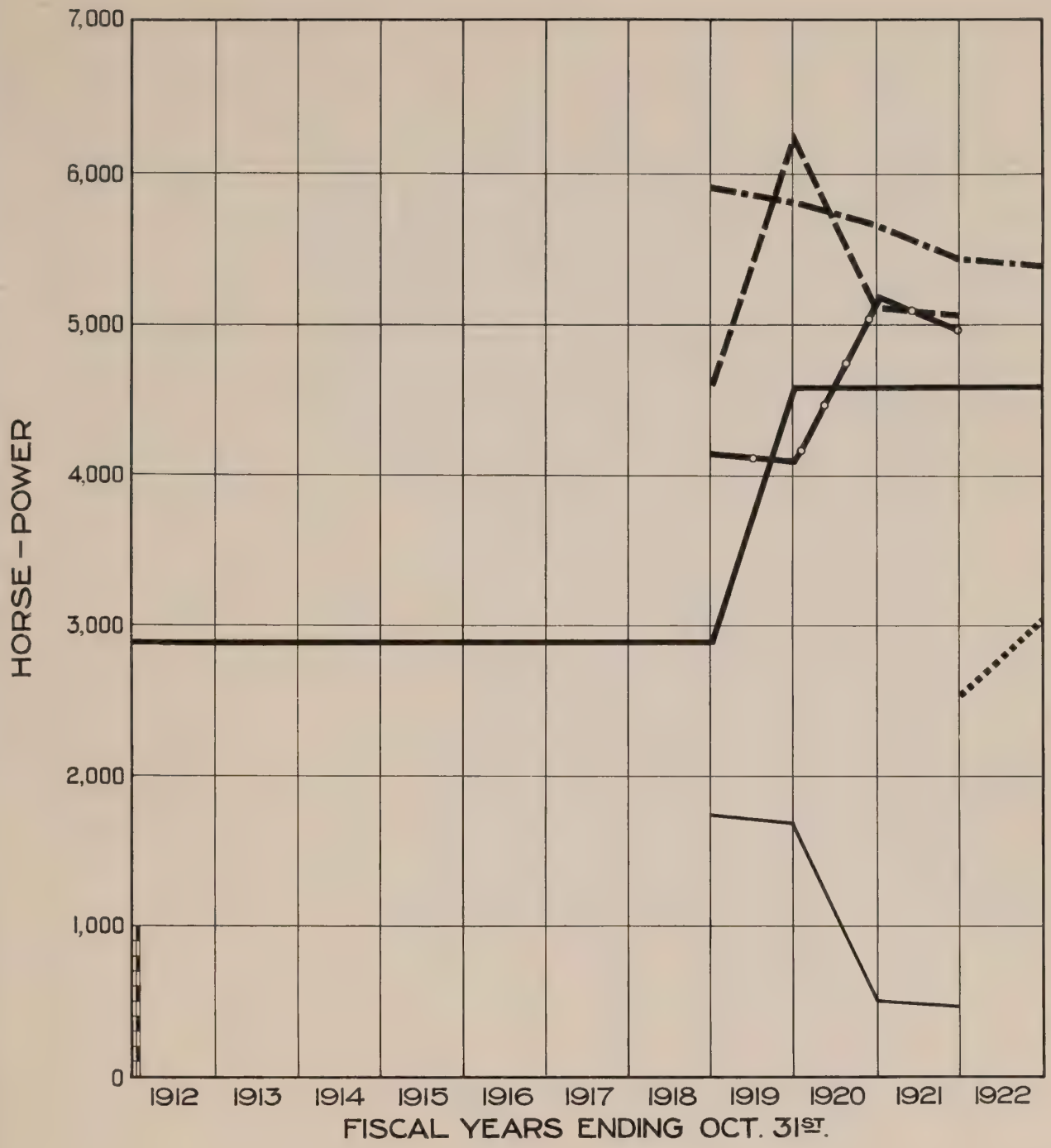
COPY

Purchased Horse-power.

The figures for the curve showing the horse-power purchased were obtained from the table on page 27, or in Exhibit I-A, in the report of Price, Waterhouse & Co. on the "Investigation of the Accounts of the Severn System", dated November 23rd, 1922, Hydro-Electric Inquiry Commission file 208-a-2, dated November 23rd, 1922, and are the average values of horse-power purchased by the Severn System from the Magania and Wasdell's Systems.

Developed plus purchased Horse-power.

The figures for the curve showing developed plus purchased horse-power were obtained by adding together the two first lines of the table on page 27.



H. P. DEVELOPED
H. P. PURCHASED
H. P. DEVELOPED PLUS PURCHASED
H. P. BILLED, TOTAL
H. P. BILLED FROM BIG CHUTE PLANT
H. P. CONSUMED, AVERAGE

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
SEVERN SYSTEM

HORSE-POWER DATA

Toronto, Feb. 26th., 1923. Made by G.&B. Checked by J.A.H.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

Average Horse-power Consumed.

The average horse-power consumed has been derived from the total number of kilowatt-hours given by the Hydro-Electric Power Commission as being the total kilowatt-hours supplied to the Severn System for the years ending October 31st, 1921 and 1922. The derivation was made by dividing the total kilowatt-hours per annum by 8,760, being the number of hours in a year, and reducing to horse-power by dividing by the factor 0.746.

Billed Horse-power.

COPY

The curve of total horse-power billed was plotted from data given in the table from which the figures for purchased horse-power were obtained.

A subdivision has been made between the horse-power developed at Big Chute and that delivered to the Severn System from the Eugenia and Wasdell's Systems.

A study of these curves shows that the demand on the Big Chute plant has increased although the total horse-power billed decreased about ten per cent. between 1918 and 1922. This is explained by the large decrease in power purchased from the Eugenia and Wasdell's Systems. The load on the Eugenia System increased to such a point that all the capacity of the Eugenia Falls plant was required to supply it.

Capital Costs per Horse-power Developed.

The diagram included as page 33 and the following table indicate the

fractional capital costs per fiscal year per rated horse-power developed at different points of delivery, based on the figures showing the capital costs of the System, and the horse-power data given above. This sheet of curves therefore, indicates the capital costs per rated plant horse-power with the spaces between adjacent curves indicating that portion of the total (delivered) capital cost per horse-power chargeable against each of the items of the table, as follows:

Table of Capital Costs per Rated Plant Horse-power Developed

	Fiscal Year Ending October 31st.			
	1914	1915	1916	1917
Power Development	$120.50	$120.50	$120.60	$124.60
Transmission Lines	104.40	109.10	115.70	140.80
Transforming and Distributing Stations	13.80	23.70	27.50	34.00
Rural Lines	-	-	-	-
Totals	$238.70	$253.30	$263.80	$299.40

COPY

Table of Capital Costs per Rated Plant Horse-power Developed (continued)

	Fiscal Year Ending October 31st.			
	1918	1919	1920	1921
Power Development	$190.30	$137.80	$141.10	$141.30
Transmission Lines	181.70	119.00	120.20	123.90
Transforming and Distributing Stations	57.60	36.60	39.00	40.10
Rural Lines	-	-	-	.12
Totals	$429.30	$293.40	$300.30	$305.90

The large rise in the unit costs in 1916, 1917 and 1918 is due to capital expenditures made for which no additional power was made available until 1919, when the new unit at Big Chute was placed in service with a consequent drop in

the unit costs.

Total Annual Revenues.

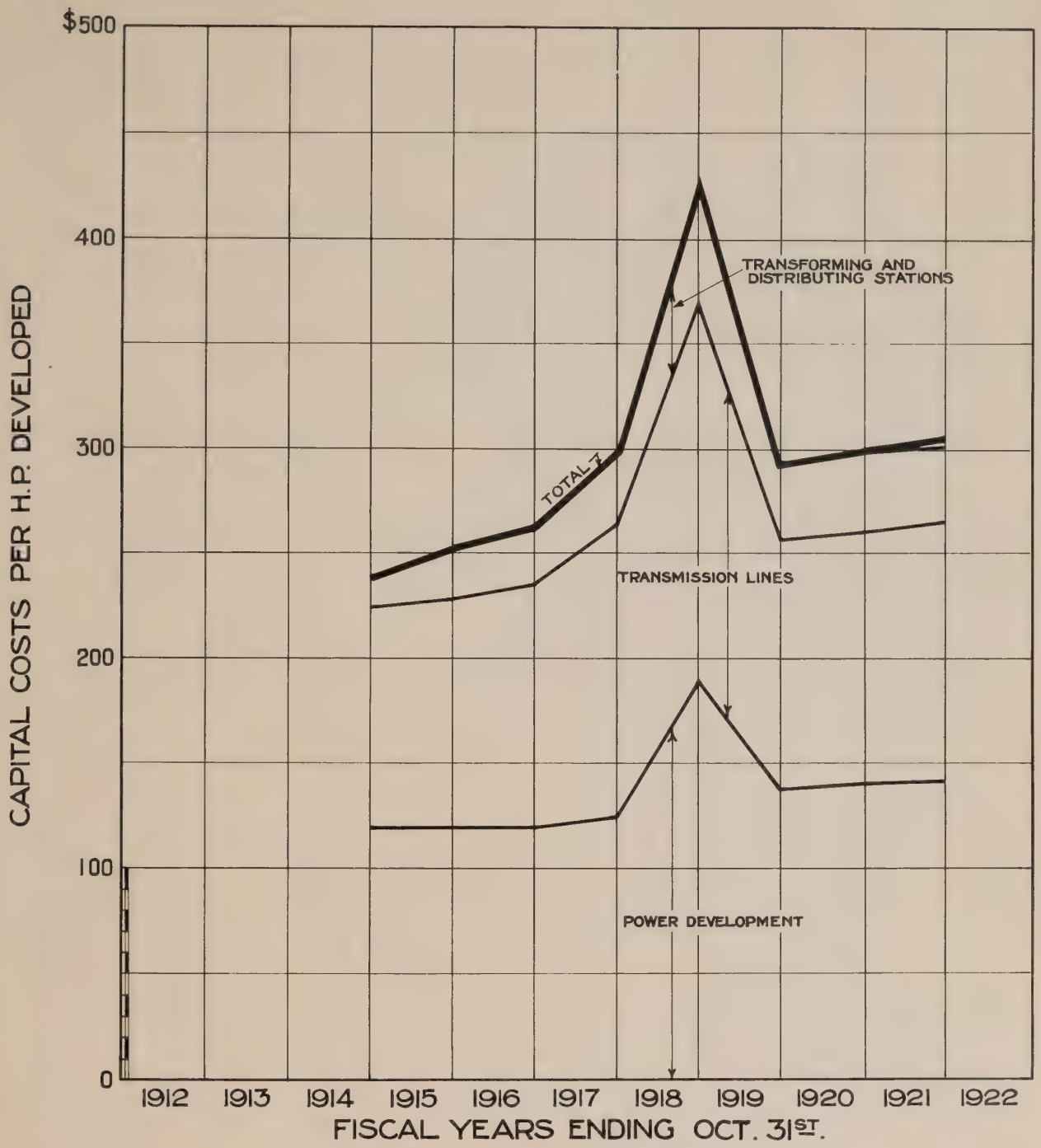
The table below, giving the total annual revenues of the Severn System, has been prepared by using the figures of Exhibit I of the report on "Investigation of Accounts of Severn System" dated November 23rd, 1922, Hydro-Electric Inquiry Commission file No.209-a-2, applying to the years 1918 to 1921 inclusive. The figures for the years 1913 to 1917 were obtained from the Annual Reports of the Hydro-Electric Power Commission. The sheet of curves on page 35 shows the revenues in graphic form.

COPY

The table of total revenues is as follows:

Period	Total Revenues per Annum
Year Ending October 31st, 1913	$ 5,323.94
Year Ending October 31st, 1914	42,160.10
Year Ending October 31st, 1915	56,755.89
Year Ending October 31st, 1916	94,694.93
Year Ending October 31st, 1917	172,792.75

Revenue from	Fiscal Year Ending October 31st. 1918	1919	1920	1921
Municipalities	$108,980.22	$171,324.01	$165,947.31	$183,912.77
Private Companies	38,852.73	32,068.01	25,345.64	28,218.45
Totals	$147,832.95	$203,392.02	$191,292.95	$212,131.22



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

SEVERN SYSTEM

CAPITAL COSTS PER HORSE-POWER DEVELOPED

Toronto, Feb. 26th., 1923. Made by G.E.B. Checked by L.H.

WALTER J. FRANCIS & COMPANY
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Total Annual Costs of Power.

The table on page 37 shows the cost of power subdivided under various headings for the years 1913 to 1921 inclusive. The figures from 1918 to 1921 inclusive are made up from Exhibit I of the Price, Waterhouse & Co. report dated November 22nd, 1922, while the figures for the years 1913 to 1917 inclusive were obtained from the Annual Reports of the Hydro-Electric Power Commission.

From this information and from the table of total revenues it may be deduced that the municipalities were charged with the cost of power and the distribution thereof, as well as with that portion of the fixed charges pertaining to the power supply.

COPY

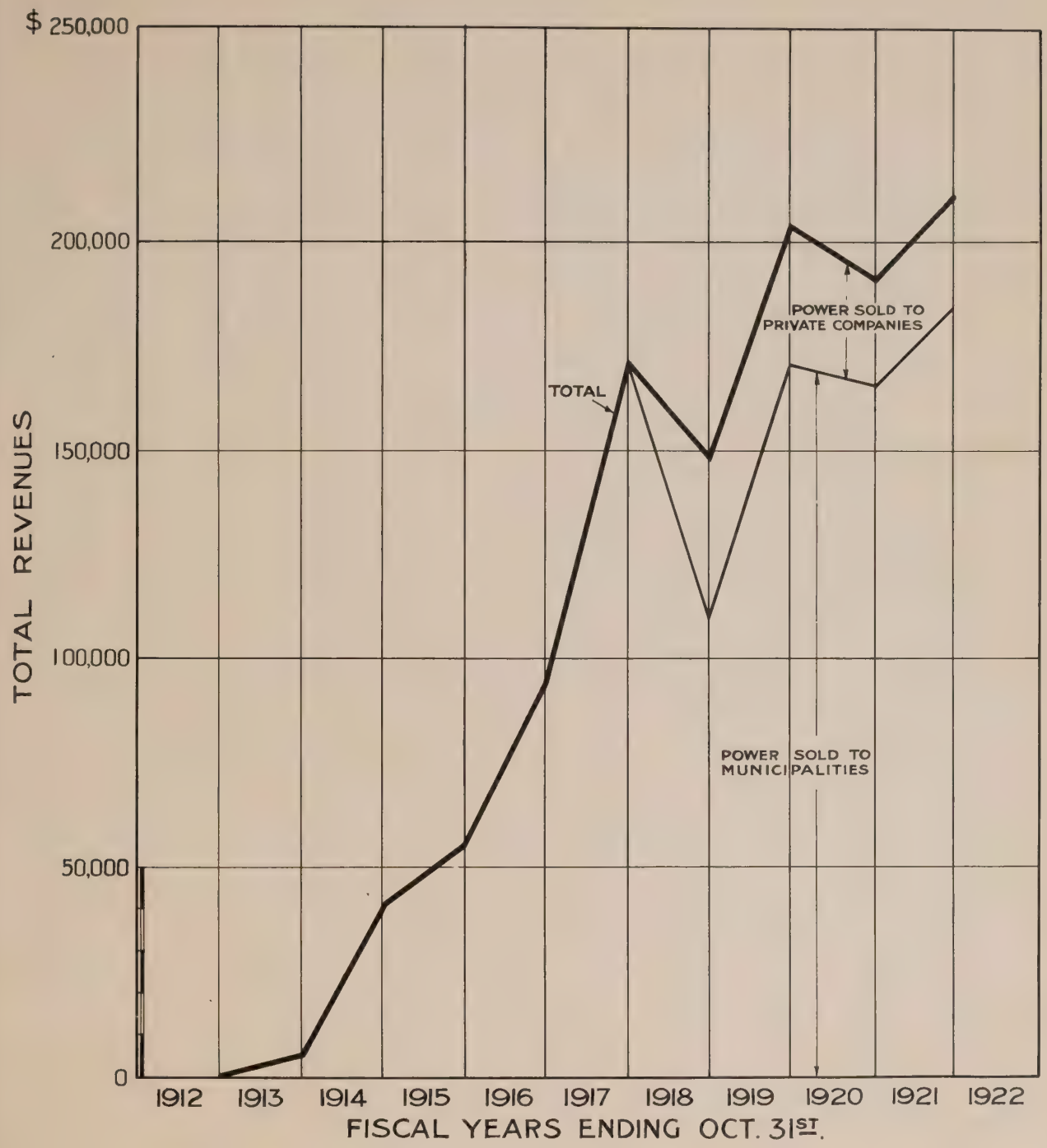
The headings under which the various costs have been grouped are as follows:

Operating Costs.

Operating costs include the wages of power house operators, linemen, station attendants and so forth, power purchased from other sources, supplies and all miscellaneous items usually grouped under this heading. The power purchased by the Severn System was a very considerable portion of the total operating costs and has been shown separately both in the tables and on the sheets of curves.

Maintenance.

Under maintenance have been placed all the items for labour and materials



HYDRO-ELECTRIC INQUIRY COMMISSION
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ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
SEVERN SYSTEM

TOTAL ANNUAL REVENUES

Toronto, Feb. 26th, 1923. Made by S.R.W. Checked by L.H.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

charged in the books of the Commission as against the individual portions of the plant, stations, lines and distributing stations, and these have been grouped together from the individual figures in the Price, Waterhouse & Co. report, to make one item.

Overhead and General Expense.

Under the heading of overhead and general expense are such items as salaries of local officers and clerks, printing and stationery, stores operation, taxes, insurance, rents, legal expense, miscellaneous office supplies and so forth, all in accordance with the Price, Waterhouse & Co. report, supplemented for the years 1913 to 1917 inclusive, from the Annual Reports of the Hydro-Electric Power Commission.

COPY

Interest, Renewals, Sinking Fund and Contingencies.

The figures for interest include all interest charges shown for the capital invested in the System.

The renewal account includes all items shown as chargeable against renewals in the same report, while the figures for sinking fund and for contingencies have been transferred directly from the report.

The sheet of curves on page 39 is the direct plotting of the figures in the table below with the spaces between adjacent curves indicating the amount chargeable against that particular item. The figures are as follows:

Table of Total Annual Costs of Power

	Fiscal Year Ending October 31st.				
	1913	1914	1915	1916	1917
Power Purchased	$3,966	$15,192	-	$ 6,366	$58,917
Operating	100	9,491	$14,772	18,152	31,041
Maintenance	-				
Overhead and General Expense	-	-			
Interest	603	15,161	29,302	29,920	32,364
Renewals	1,655	2,316	12,692	40,256	50,470
Totals	$6,324	$42,160	$56,766	$94,694	$172,792

Table of Total Annual Costs of Power (continued)

	Fiscal Year Ending October 31st.			
	1918	1919	1920	1921
Power Purchased	$ 43,667	$ 42,470	$ 12,853	$ 18,782
Operating	11,390	15,498	15,467	20,068
Maintenance	19,098	21,134	17,700	24,696
Overhead and General Expense	8,119	20,145	26,772	26,455
Interest	35,746	55,041	62,755	62,716
Renewals	24,576	34,930	37,883	37,905
Sinking Fund	3,758	12,717	16,439	19,046
Contingencies	1,478	1,457	1,423	1,360
Totals	$147,832	$203,392	$191,292	$211,028

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It will be noted that in the year 1921 there is a small difference between the total revenue and the total cost of power amounting to $1,102.50, which represents the profit on power sold to private companies, undistributed to municipalities. It is explained that this amount has been transferred to the reserve for contingencies, thus making the total revenues and the total costs of power balance in each year.

Percentage Costs of Power.

The table below and the sheet of curves included as page 41 show the cost figures as percentages of the total cost of power per annum, and these are included as a method of comparison with other systems or similar properties:

Table of Annual Costs Subdivided by Percentages

	Fiscal Year Ending October 31st.			
	1918	1919	1920	1921
Power Purchased	29.6	20.9	6.7	8.9
Operating	7.7	7.6	8.1	9.5
Maintenance	12.5	10.4	9.3	11.7
Overhead and General Expense	8.5	9.9	14.0	12.6
Interest	24.2	27.1	32.8	29.7
Renewals	16.6	17.2	19.8	18.0
Sinking Fund	2.5	6.2	8.6	9.0
Contingencies	1.0	.7	.7	.6
Totals	100.0%	100.0%	100.0%	100.0%

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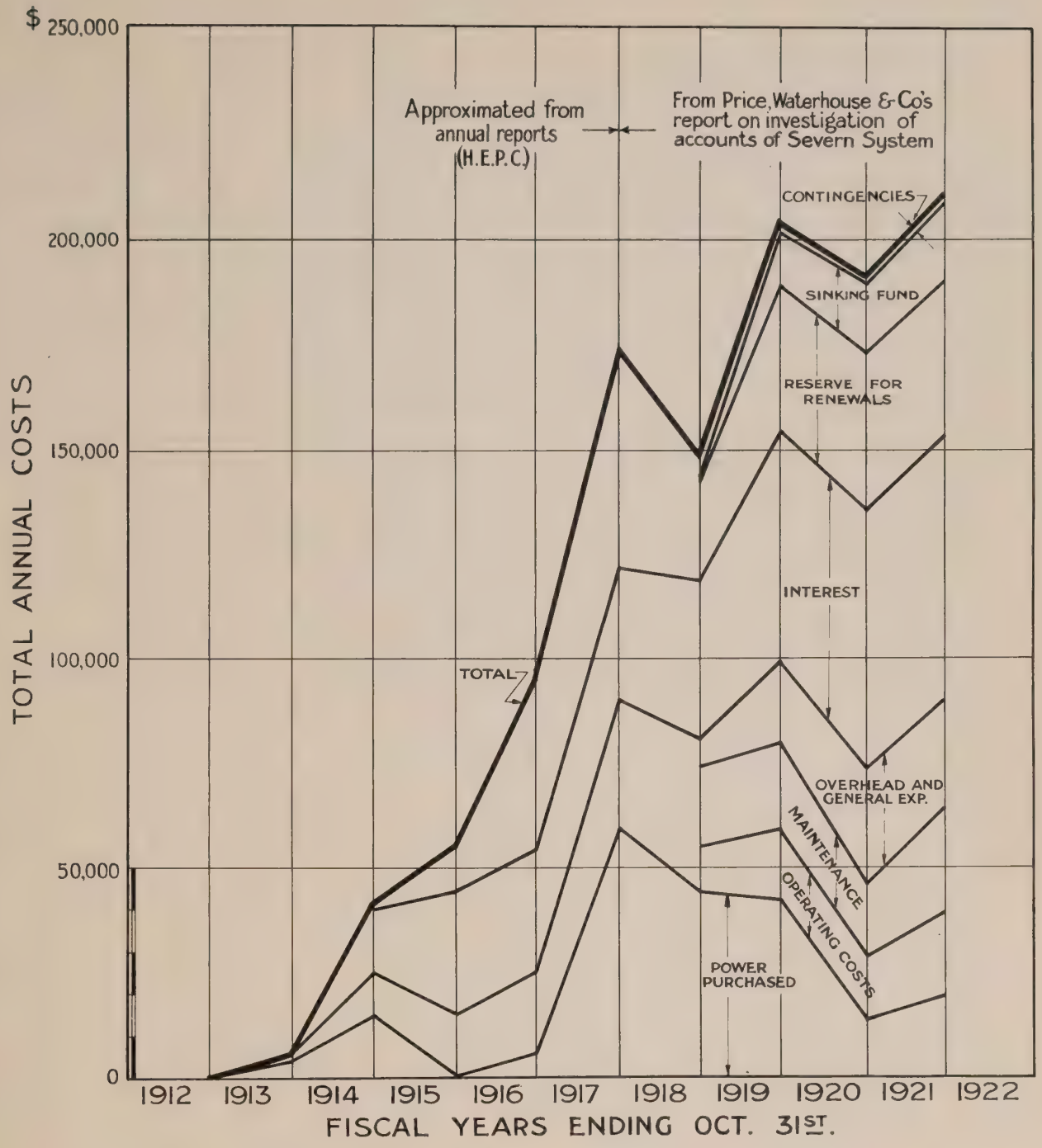
Analysis of Reserve Accounts.

Renewals Account.

The table on page 43, and the sheet of curves included as page 45 show the amounts set aside as reserve for renewals as they exist at the present time on the books of the Hydro-Electric Power Commission. As stated on page 16 in the report of Price, Waterhouse & Co., the reserve is based on an annual



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
SEVERN SYSTEM

TOTAL ANNUAL COSTS

Toronto, Feb. 26th, 1923. Made by S.R.W., Checked by L.L.W.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

charge of 2.75 per cent. of the depreciable capital investment, together with interest at the rate of 4 per cent. per annum on the balance. This follows the usual method, known as the sinking fund basis, for providing a fund for renewals for plant deteriorating in use. The useful life in years of each portion of the depreciable capital invested, the replacement cost, and the residual or scrap value of the articles at the end of this time are all estimated, and an amount is set aside which when compounded at an assumed earning rate will retire the total amount to be provided for at the end of its own particular useful life. It is understood that it is the practice of the Hydro-Electric Power Commission to spend sufficient money on maintenance account each year so as to keep each and every portion of the system in a condition to operate in accordance with the requirements of economical production, which it is stated is considered to be about seventy-five per cent. as good as its original new condition. This being so, it was considered in this report that the renewal accounts should be studied in connection with and applied to the renewal of only twenty-five per cent. of the capital concerned.

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The annual rate of 2.75 per cent., we are advised, is based upon a re-classification of the various properties in connection with the Severn System, from which the engineers of the Hydro-Electric Power Commission deducted certain properties of a substantial nature which they considered should have no provisions for renewals, for example reinforced concrete dams, floodage, water rights and so forth. During the past months the Engineering Department of the Hydro-Electric Power Commission, together with the heads of the various departments, have been carefully studying the question of depreciation rates, and we

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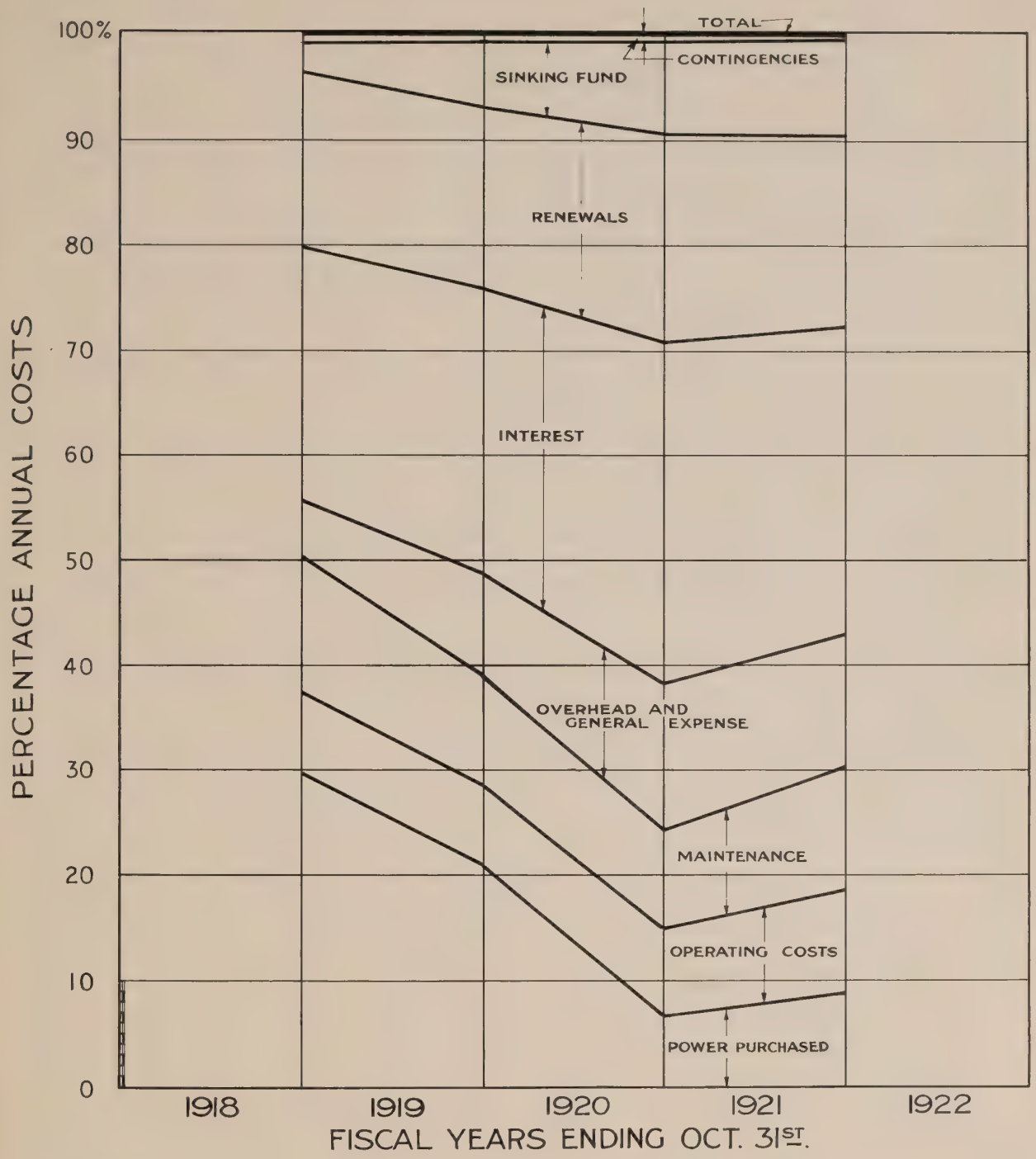

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
SEVERN SYSTEM
ANNUAL COSTS SUBDIVIDED BY PERCENTAGES
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are advised that they are now considering a further reduction of the renewal allowances, to be made retroactive for a period of years. This would have the effect of building up the reserve fund in future at a slower rate, and of correspondingly reducing the annual cost, and consequently reducing the total annual cost of power.

There are one or two points which should receive careful consideration in dealing with the question of these reserved for renewals. One is the proposed change in the estimated length of useful life of the various portions of the equipment, which will materially affect the annual allowances, and the other is the question of the proper rate of interest to be chosen in estimating the earning power of the invested reserve funds.

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A strict theory of the earning power of the renewal fund would take into consideration not only the method of investing the fund, for example whether it be used in making extensions and betterments in the System as has actually been done, or invested in separate securities and treated like a trust fund, but also the rate of annual interest, which should be adjusted each year in accordance with the actual value of money. The legal limitations of the allowable investment of the fund should also be kept in mind in this connection.

At the present time the total depreciable capital is probably in the neighborhood of one and one-quarter millions of dollars, while the reserve fund amounts to two hundred and twenty-seven thousand dollars. As a large portion of the total depreciable capital has been invested within the past few years, and as the useful life of each portion of the equipment is really in the early stages, it would therefore appear that the present total accumulations

of the fund as applicable to twenty-five per cent. of the total depreciable capital, is somewhat larger than is necessary, taking all the above factors into consideration. The reserve for renewals on the basis of 2.75 per cent. is as follows:

Table of Reserve for Renewals

Period	Provision	Interest	Together
From 1912 to October 31st, 1916	$ 54,158	$ 2,055	$ 56,213
Fiscal year ending October 31st,			
1917	20,991	2,241	23,232
1918	24,577	3,178	27,755
1919	34,930	4,288	39,218
1920	37,883	5,857	43,740
1921	37,905	7,606	45,512
Together	$210,444	$25,225	$235,668
Miscellaneous deductions			8,321
Total at October 31st, 1921			$227,347

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Sinking Fund.

The study of the finances of the System shows that a reasonable amount has been set aside as sinking fund to provide for the financial obligations concerning the properties. The total amount is given in the Price, Waterhouse & Co. report as $59,961, of which amount $43,614 was charged to municipalities and $16,347 to companies.

This amount shows the aggregate amount of the sinking fund collectable at October 31st, 1921, from eleven municipalities which have taken power for six

years or longer, the initial charge being made in the sixth year's power cost. The sinking fund charges deferred at October 31st, 1921, amounted to $44,741, representing deferments, as permitted by the Act, for a period of from two to four years in respect of sixteen municipalities.

It is interesting to note that in the case of Victoria Harbor there is apparently a considerable difference in the methods of billing for power to that stipulated in the contract with that municipality. Price, Waterhouse & Co. state in their report that Victoria Harbor is supposed to be charged $16.50 per horse-power per annum for all power taken at the interswitching station at Waubaushene. The clauses in the present standard contract form of the Hydro-Electric Power Commission relating to sinking fund and to the trusteeship of the Commission are also stated to be omitted from the Victoria Harbor contract. Apparently Victoria Harbor is being billed on the cost basis, including sinking fund, instead of in accordance with the contract it has with the Commission. The cost basis is stated to be between $40.00 and $50.00 per horse-power per annum.

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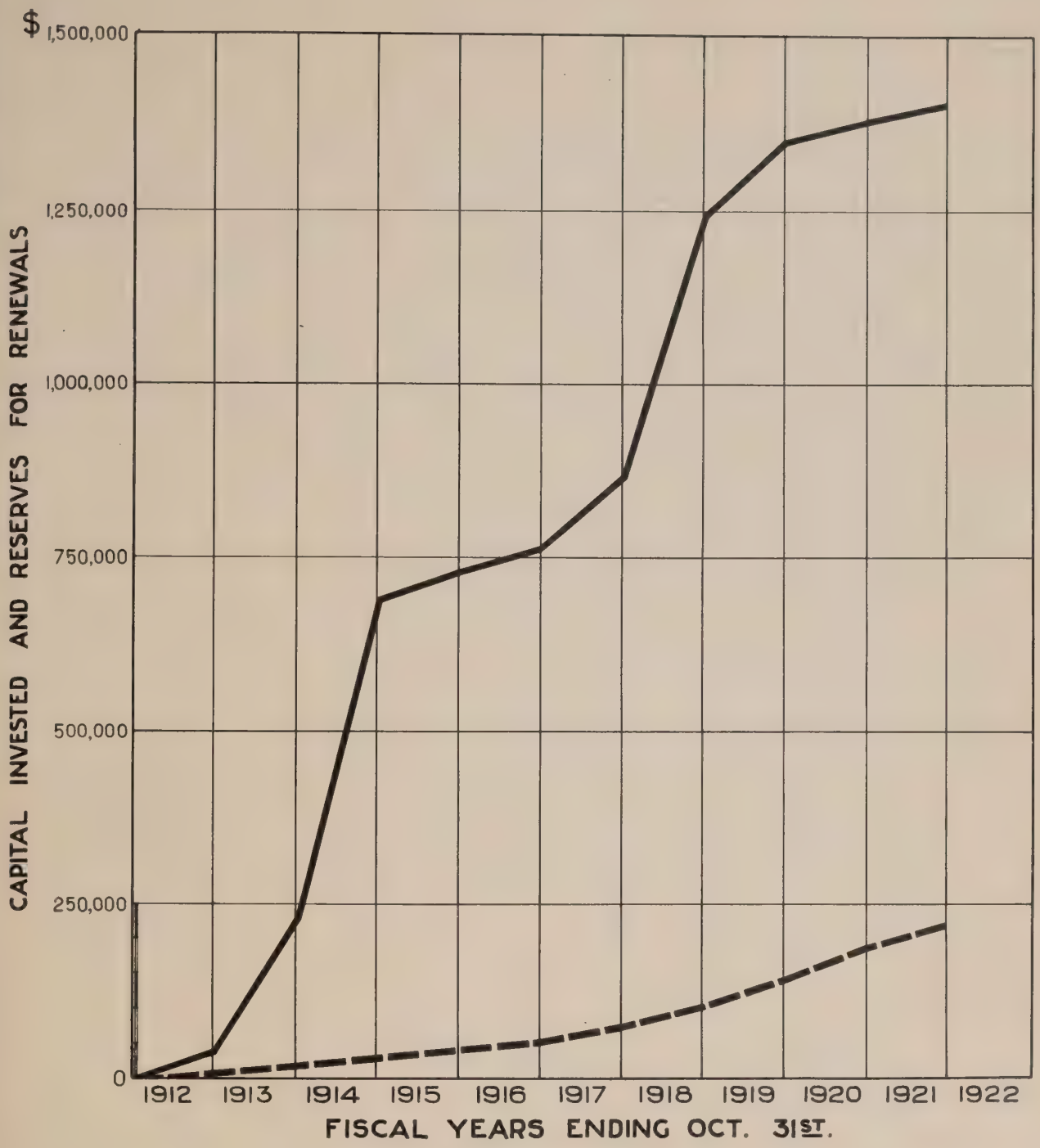
Certain individual customers are also apparently credited with large sinking fund payments. The question of these customers being charged with sinking fund and so, theoretically, at least, obtaining an equity in the System, should be studied and the accounts adjusted if necessary.

Reserve for Contingencies.

A study of the accounts of the System shows that up to the end of 1921, a



TOTAL INVESTED CAPITAL
TOTAL RENEWAL RESERVES, INCLUDING INTEREST

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
SEVERN SYSTEM

RESERVES FOR RENEWALS

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total reserve for contingencies has been set aside amounting to $14,240 made up of an annual charge of 25 cents per horse-power on the average power billed to the municipalities and to sundry customers, and of certain profits realised on sales to sundry customers, together with the profit from the sales of miscellaneous equipment, and an allowance for interest at four per cent. per annum. From this sum has been deducted about $7,112, including $5,919 loss on a Canadian General Electric generator transferred from Collingwood to the Eugenia System; an amount of $556.00 being the installation and renewal costs of a 66-inch gate valve transferred to stores, and $298.00 covering the cost of repairing a transformer damaged by lightning.

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Considering the heavy losses which might be occasioned through catastrophe, it is felt that the total amount at the credit of this fund, namely about $7,128, should be augmented by increasing the annual allowance for contingencies, and when a reserve of say $20,000 or $30,000 will have been built up, the rates can be readjusted to suit the conditions found after several further years of experience.

Discussion of Deficits and Surpluses.

The records show that the System as a whole has been billed with the cost of power in accordance with the book-keeping methods of the Hydro-Electric Power Commission since 1918, and that there are now no deficits or surpluses for the System as a whole. This does not take into account the local distribution in the various municipalities, which is done by the municipality itself or by a

separate commission in such municipality, and where the profits or losses are not included in the accounts of the Hydro-Electric Power Commission for the Severn System.

Revenues and Costs per Horse-power per Annum.

In order to reduce the total revenues and total costs of operation to a basis where these would be comparable with other systems and to agree with the usual practice of similar companies and of distribution authorities, a set of diagrams has been prepared to show the revenues per horse-power per annum from different main groups or classifications of consumers and to show the revenue per horse-power per annum for different bases of horse-power.

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In a similar manner, the total costs have been reduced to costs per horse-power per annum for different bases of horse-power and have also been analyzed to show the total annual costs subdivided into fractional amounts chargeable against each kind of expense based on the horse-power rating of the plant and also on the average horse-power billed. The following series of diagrams with the table of figures for each, show these various items in detail.

The various revenues for each classification of horse-power are given in the following table, and on the sheet of curves on page 49 hereof.

Table of Revenues per Horse-power per Annum

Revenues per Horse-power	Fiscal Year Ending October 31st. 1918	1919	1920	1921
Developed	$50.90	$44.21	$41.58	$46.12
Developed plus Purchased	31.81	32.29	37.41	41.82
Consumed	-	-	-	82.60
Billed	25.04	34.91	35.60	38.99

Annual Costs per Horse-power.

The three sheets of curves on pages 51, 53 and 54, and the tables on page 50 show the details of the costs per horse-power per annum on different bases. The figures from which the curves were plotted are the figures for the operating costs given in the table on page 37 divided by the figures for the various classes of horse-power already given in the text. The sheet of curves included as page 51 indicates the total costs per horse-power per annum for the different classifications of horse-power already discussed. It will be noted that the total costs per horse-power in the fiscal year 1921 does not balance with the total revenue per horse-power on account of the fact that in this year a small profit was shown on the power supplied to sundry customers, but this was later added to the reserve for contingencies.

The sheet of curves on page 53 entitled "Subdivided Costs per Horse-power Developed", indicates the subdivision of the total annual costs as between operating, maintenance, overhead and general expense, interest, renewals, sinking fund and contingencies, divided by the total amount of horse-power developed in the Big Chute plant. Similarly the sheet of curves on page 54 indicates the

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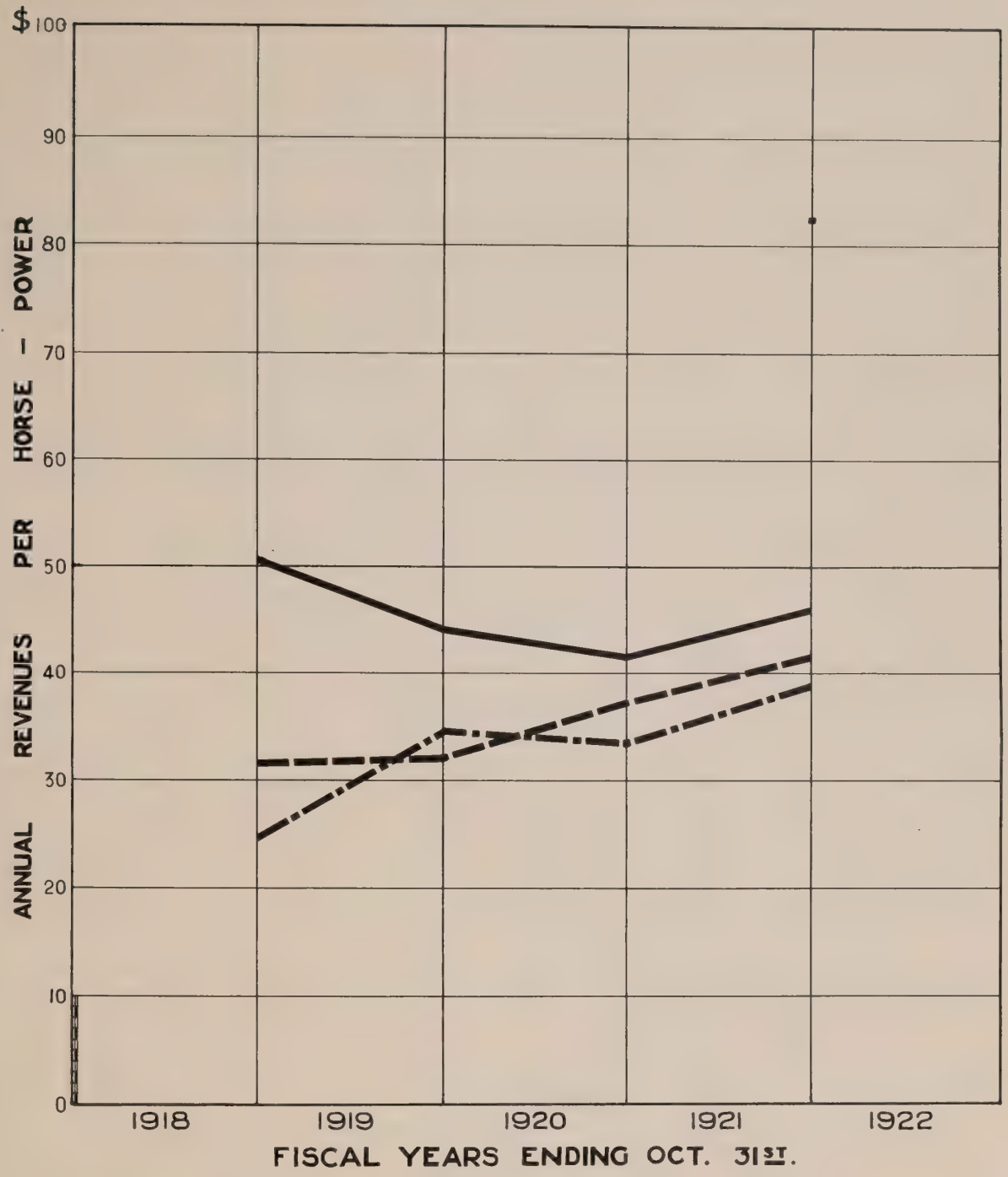

REVENUE PER H.P. DEVELOPED
" " " " " PLUS PURCHASED
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" " " " BILLED

HYDRO-ELECTRIC INQUIRY COMMISSION
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SEVERN SYSTEM

REVENUES PER H.P. PER ANNUM
VARIOUS H.P. BASES

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subdivided costs per horse-power billed:

Table of Total Costs per Horse-power per Annum

	Fiscal Year Ending October 31st. 1918	1919	1920	1921
H.P. Developed	$50.90	$44.21	$41.58	$45.87
H.P. Developed plus Purchased	31.81	32.29	37.41	41.60
H.P. Consumed	-	-	-	82.17
H.P. Billed	25.04	34.91	33.60	38.78

Table of Subdivided Costs per Horse-power Developed

	Fiscal Year Ending October 31st. 1918	1919	1920	1921
Power Purchased	$15.06	$ 9.24	$ 2.80	$ 4.08
Operating	3.94	3.37	3.36	4.35
Maintenance	6.59	4.53	3.86	5.37
Overhead and General Expense	2.70	4.37	5.81	5.76
Interest	12.32	11.98	13.62	13.62
Renewals	8.49	7.58	8.25	8.25
Sinking Fund	1.29	2.77	3.57	4.14
Contingencies	.51	.32	.31	.30
Totals	$50.90	$44.21	$41.58	$45.87

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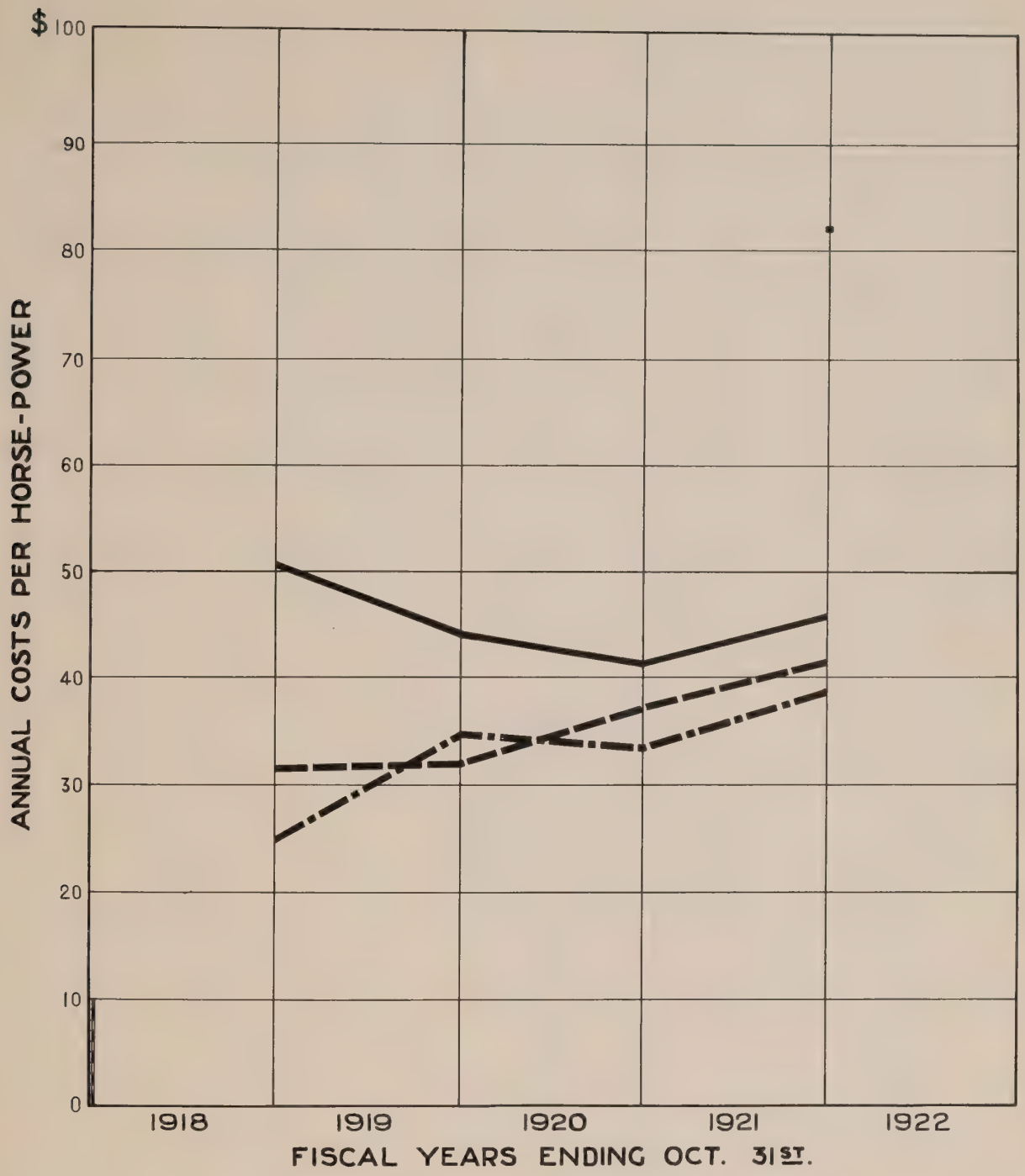
Table of Subdivided Costs per Horse-power Billed

	Fiscal Year Ending October 31st. 1918	1919	1920	1921
Power Purchased	$ 7.47	$ 7.32	$ 2.26	$ 3.45
Operating	1.92	2.66	2.72	3.68
Maintenance	3.23	3.62	3.11	4.54
Overhead and General Expense	1.36	3.45	4.70	4.86
Interest	6.04	9.44	11.01	11.52
Renewals	4.15	5.99	6.66	6.98
Sinking Fund	.63	2.18	2.89	3.50
Contingencies	.24	.25	.25	.25
Totals	$25.04	$34.91	$33.60	$38.78



COSTS PER H.P. DEVELOPED
" " " " " PLUS PURCHASED
" " " " CONSUMED
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ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

SEVERN SYSTEM

TOTAL COSTS PER H.P. PER ANNUM
VARIOUS H.P. BASES

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Kilowatt-hour Data and Annual Revenues and Costs per Kilowatt-hour.

The engineers of the Hydro-Electric Power Commission state that prior to 1921 there is no reliable record of the number of kilowatt-hours supplied to the Severn System. It is estimated by them that the total kilowatt-hours consumed in 1921 for the Severn System amounted to 16,784,781. This being the only figure available up to that date it is impracticable to plot diagrams for kilowatt-hour consumption or costs, and the only thing possible is to show an analysis or subdivision of the total costs based on the average horse-power consumed and the kilowatt-hours for 1921. For 1922 the kilowatt-hours are about 19,996,108. The figures are as follows:

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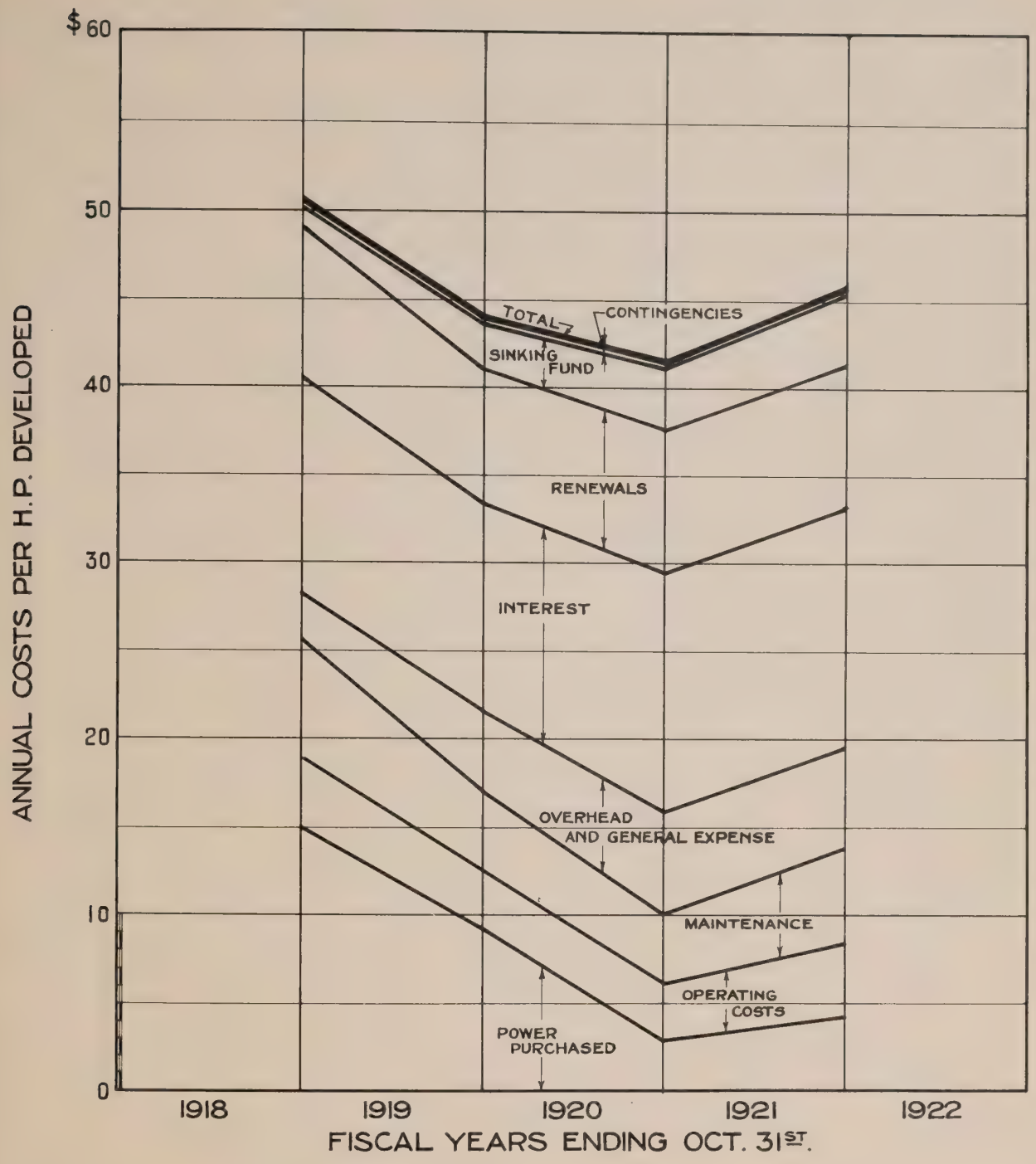
Table of Subdivided Costs per Average Horse-power and per Kilowatt-hour Consumed in 1921

	Dollars per H.P.	Cents per K.W.H.
Power Purchased	$ 7.31	0.112
Operating	7.79	0.119
Maintenance	9.63	0.147
Overhead and General Expense	10.30	0.158
Interest	24.43	0.374
Renewals	14.76	0.226
Sinking Fund	7.42	0.113
Contingencies	.53	0.008
Totals	$82.17	1.257

Since, in this year, the accounts show a small profit on the sale of power to sundry customers, the revenue per average horse-power consumed and the revenue per kilowatt-hour for 1921 are slightly higher than the total costs.

The revenue per average horse-power consumed in 1921 was $82.60, and the



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W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
SEVERN SYSTEM
SUBDIVIDED COSTS PER ANNUM PER H.P. DEVELOPED
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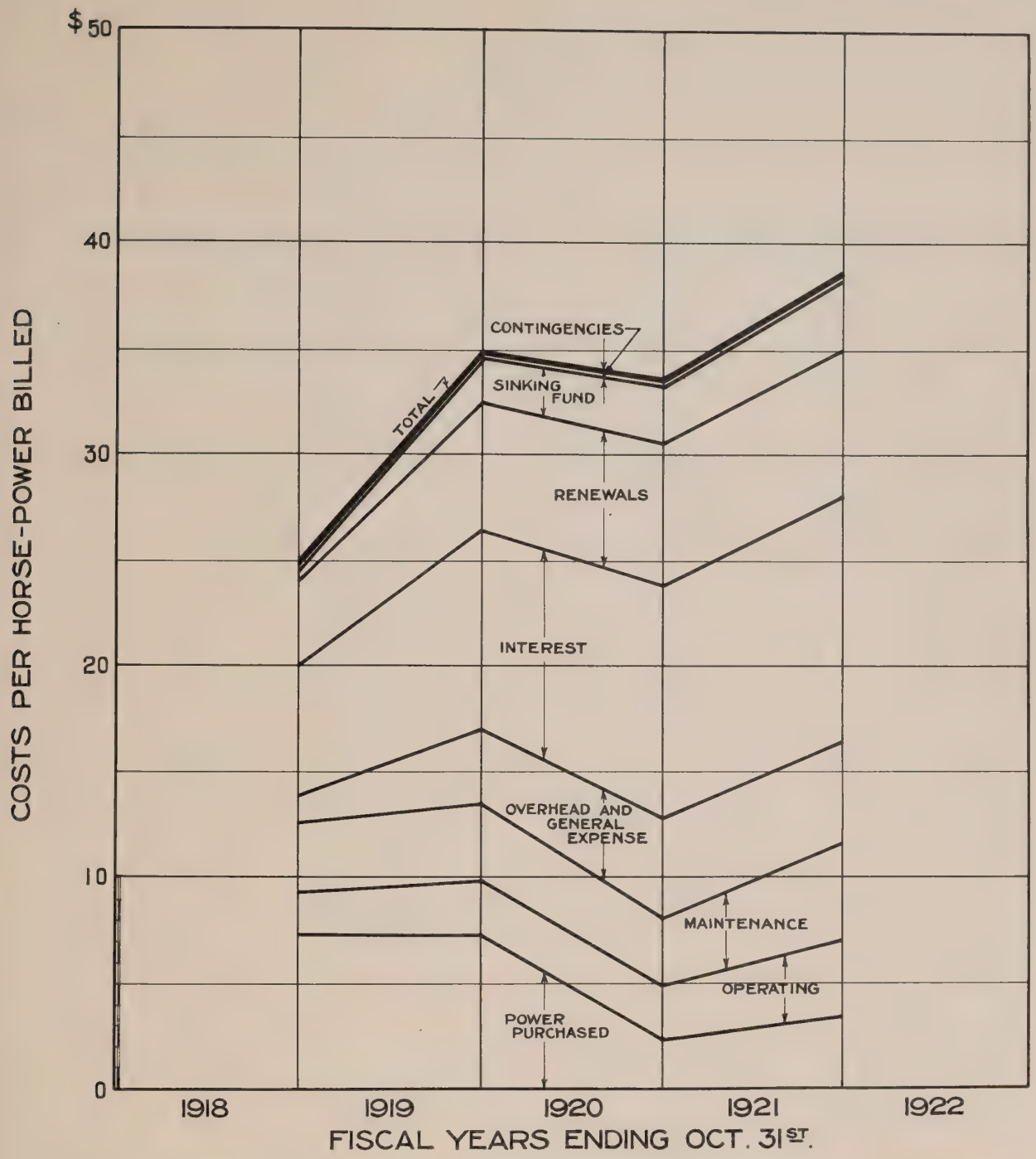

HYDRO-ELECTRIC INQUIRY COMMISSION
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ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

SEVERN SYSTEM

SUBDIVIDED COSTS PER ANNUM PER H. P. BILLED

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revenue per kilowatt-hour was 1.265 cents.

The following tables, and the sheet of curves included as page 57 show the kilowatt-hours per consumer supplied for dif erent purposes in the various municipalities of the Severn System for the year 1921, and also show the kilowatt-hours consumed for various classes of service averaged for the whole of the Severn System from 1918 to 1920 inclusive. The figures indicate the difficulty of comparing one place with another, as will be seen by the wide variation in the details given for the various places.

Table of Power Consumption by Municipalities

COPY

	K. W. H. per Domestic Consumer	Calendar Year 1921 K. W. H. per Commercial Light Consumer	Horse-power per Power Consumer
Alliston	276	520	10
Barrie	543	1,450	18
Beeton	229	453	46.5
Bradford	320	470	21.5
Coldwater	333	420	25.5
Collingwood	550	126	16
Cookstown	270	352	20.5
Creemore	117*	352	11.5
Elmvale	179	340	24
Midland	690	179	25
Penetanguishene	384	1,090	21
Port McNicoll	284	536	3
Stayner	244	524	14
Thornton	197	295	-
Tottenham	249	278	3
Victoria Harbor	301	892	-
Waubaushene	208	467	3

* 1920 figures

The figures for the average number of kilowatt-hours used for domestic

lighting and for commercial lighting throughout the System, for 1918, 1919 and 1920, are shown in the table below:

Table of Kilowatt-hour Consumption - Various Classes

	Calendar Years 1918	1919	1920
K.W.H. per Domestic Light Consumer	296	324	421
K.W.H. per Commercial Light Consumer	792	814	928

Summary.

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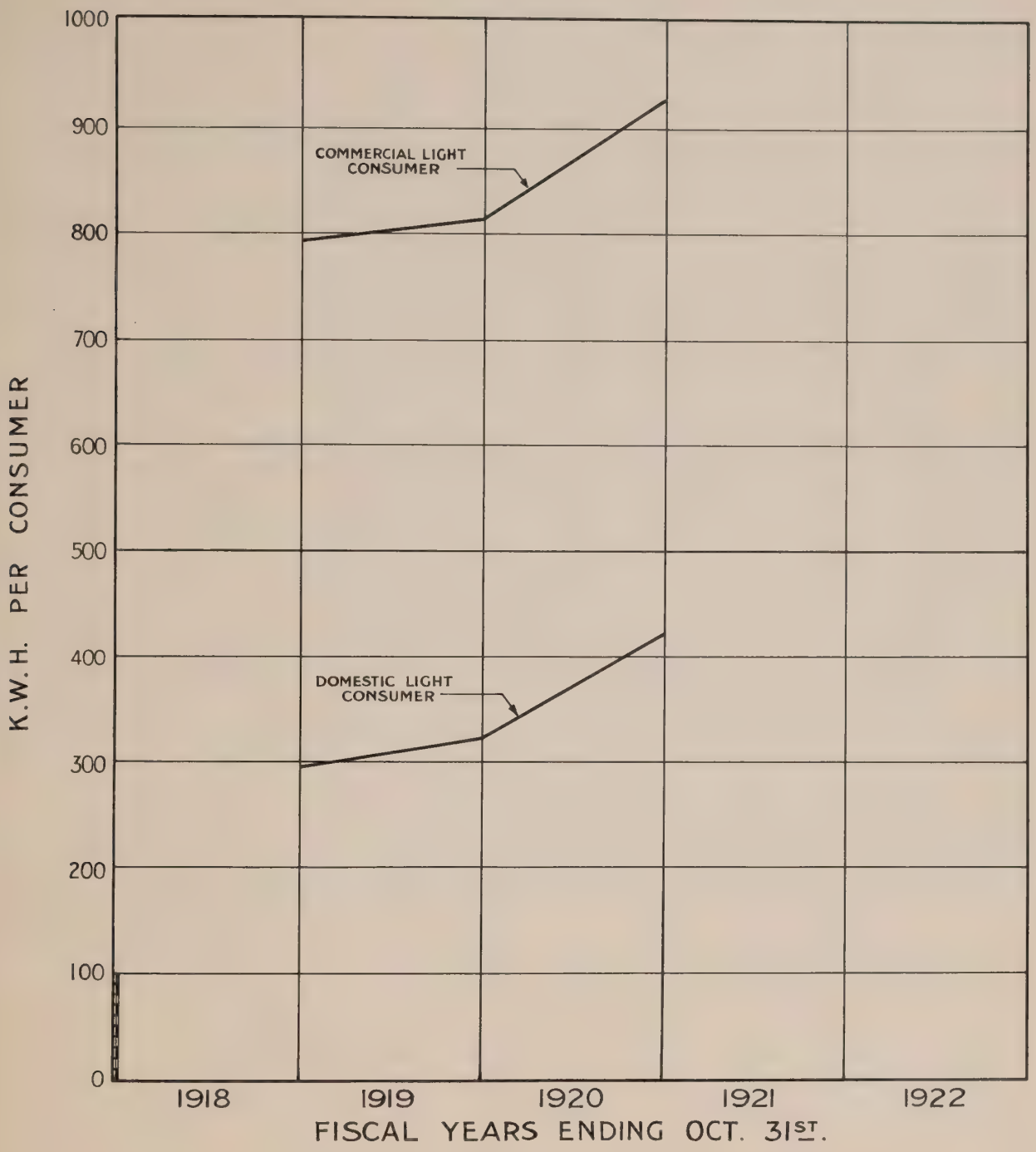
A summary of a number of the more salient points which have been studied and discussed in the foregoing report may be of advantage in continuing the consideration of the economics of the Severn System. They are as follows:

(1) The capital costs of the Severn System contain an item of about $124,000 representing the value of the intangibles taken over with the Big Chute plant. The capital costs of the Big Chute generating plant show reasonable construction costs, and now stand at about $142 per horse-power.

(2) Capital costs projected for 1922 and 1923 amounting to about $475,000 will, if carried out as contemplated, make the total investment in the Severn System approximately $1,900,000 at October, 1923.

Of this contemplated expenditure about $275,000 is stated to be for the Port Severn power development, and about $100,000 for miscellaneous extensions to transmission lines and distributing stations, and about $100,000 for extensions to rural lines.

The estimated development of the Port Severn power plant represents a capital cost per horse-power of about $230 based on the assumed regulated flow. If 1,500 horse-power be developed, the capital cost per horse-power installed would be about $183. These figures are fairly high when it is considered that the dam is already built at the expense of the Federal Government, but as the power will be used locally the transmission line costs will be low.



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
SEVERN SYSTEM
KILOWATT-HOUR CONSUMPTION FOR VARIOUS CLASSES
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(3) To facilitate future economic studies, and to assist in operating efficiency it would be well to consider keeping accurate records of kilowatt-hours used at each principal consuming point on the System.

(4) The market for power has been well covered in the district. The density indicates a high percentage of consumers per capita of population. The demand for electricity is apparently still growing and indications are that further sources of power supply must soon be provided. The ultimate demand for power and ultimate sources of supply should be considered in the near future because the local economical power sites will probably soon all be utilized.

(5) The reserve for renewals should be carefully considered in its relation to the recently revised estimated useful life for various portions of the property, and also adjusted to allow for the actual cost of money year by year.

(6) The reserve for contingencies has been called upon to replace properties damaged or destroyed by catastrophe, to nearly one-half the total accumulations. This indicates that the reserve for contingencies might with advantage be increased and yearly results noted so as to eventually devise a proper yearly allowance for the fund.

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(7) The operating records indicate that the System is being operated so as to supply power at cost, there being practically no difference between total revenues and total costs as shown on the Commission's books.

(8) The question of sinking funds should be studied in its relation to the case of Victoria Harbor and of those individual consumers who are apparently building up an equity in the System without actually being partners in it.

Walter J. Francis

Consulting Engineer.